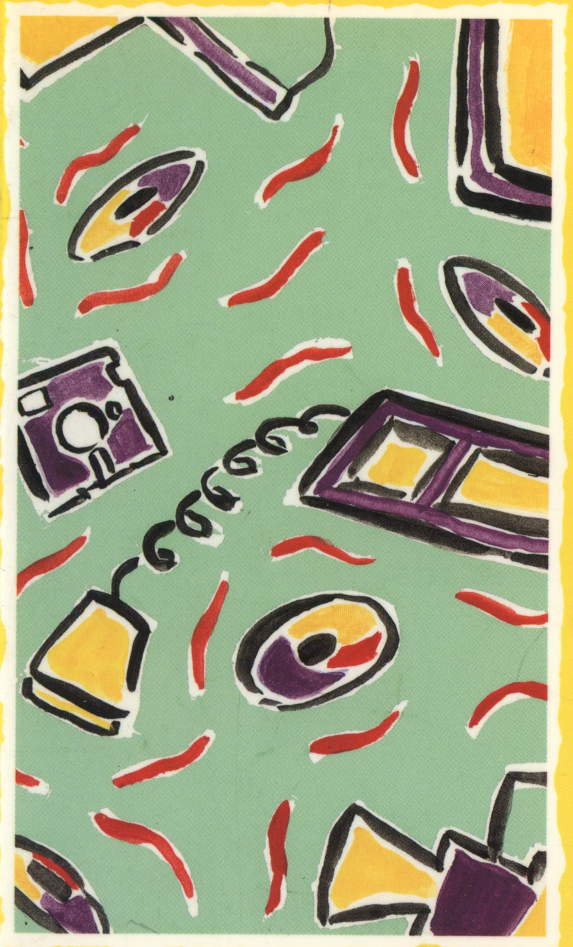

CD-I Designers GUIDE

Signe Hoffos with Dr. Graham Sharpless, Phillip Smith and Nicholas Lewis from New Media

THE CD-I DESIGNER'S GUIDE

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Preface

New Media commissioned Signe Hoffos to write this book as an introduction to CD-I. It is aimed at all those with a professional interest in interactive multimedia. It is not a technical manual, but an overview of CD-I, in context alongside rival technologies, with extensive accounts of real experience in the development of titles.

The early chapters have been kept general to serve as an introduction to the current range of interactive multimedia systems. They describe the different platforms, as well as the marketing issues and design processes essential to the development of virtually any title, for any audience in any medium. Later sections – which address CD-I technology more specifically – can get rather technical, but we hope that the whole remains thoroughly readable.

The people responsible for the content of this book have been involved longer than most in CD-I and in creating products for it. CD-I was announced to the world by Philips and Sony in March 1986 – and this preface was written exactly six years later. Philip Smith started planning the world's first commercial CD-I title – the *Grolier Multimedia Encyclopedia* – in August 1986. Nicholas Lewis joined him at New Media shortly afterwards. Graham Sharpless, in the meantime, was busy first at Philips Research Laboratories and then in Eindhoven, editing the CD-I technical specification (*The Green Book*) in 1987.

All three have been designing CD-I titles full-time since then. With Signe Hoffos, they wrote the *CD-I: A Designer's Overview*, which Philips published in 1988 with Kluwer and McGraw-Hill, and which also appeared in Japanese under the imprint of Yamaha. This new book has been written by Signe Hoffos, who has been writing about interactive multimedia for over ten years.

Mid-1992 – only months after the launch of CD-I by Philips in the USA, and at the moment of the Japanese and European roll-outs – seems the right time to tell the story

anew and to pass on the current perceptions of a group of people with that rare commodity in any 'emerging technology' – experience.

This is not just a *CD-I Designer's Guide*, but also an *Interactive Multimedia Designer's Guide*. There are other technologies now emerging – CDTV (the first multimedia product to reach the consumer market), DVI (from the people who put the wind up Philips by showing 'full-motion video' – or maybe not – in 1987), not to mention MPC, Ultimedia, and something from Apple.

If this book, serving as an introduction, encourages just a few people to go out, break all the rules, and create some exciting titles – it will have done its job.

Dick Fletcher
New Media

Introduction

The magic words 'interactive', 'multimedia' and 'compact disc' can cast their spell in boardrooms and showrooms from Tokyo to Rome. Individually or together, they can excite and confuse in equal measure. At the drop of a buzzword, technical services are dashing off to buy new kit, marketing is drawing up a radical new campaign, and senior management is left to wonder whether they still understand the conversation.

These new media are attracting attention not only from audio-visual production and computing, but also from publishing, marketing, training, education and broadcasting. Interactive multimedia provides a fresh range of communication tools for people who want to apply new ideas to real tasks in a variety of environments.

WHO SHOULD READ THIS BOOK?

This book was designed to provide a comprehensive guide to interactive multimedia, and CD-I in particular, for everyone who is interested in this rapidly-expanding market, from venture capitalists to nascent programme-makers. This includes:

- Anyone who has heard buzzwords such as interactivity and multimedia, and now wants to know more.
- Those already familiar with the basic concepts of interactivity and multimedia, who now want to acquire specific production skills, particularly to work in CD-I.

The first group represents professionals who may work alongside a production team, and make critical decisions about budgets, markets and related issues, and so need some appreciation of basic principles, but no specific production skills – investors, senior managers, financial advisers, consultants and subject experts.

The second group comprises all those who actually do want to become programme-makers – that is, people already working in fields such as computer-based training, electronic publishing or interactive video, who need only the specific extra skills which CD-I demands, as well as people from fields such as publishing, broadcasting, corporate communications, entertainment, marketing and advertising, who have creative and technical skills in other media, but need to know a good deal more about the particular demands of multimedia and CD.

HOW TO READ THIS BOOK

Some readers will undoubtedly study this whole book from start to finish with equal attention. However, the gradual progress from basic concepts to technical details means that many will be able to concentrate on the chapters which answer their personal needs, and skim the rest.

The book includes an extensive glossary and index, and a multimedia timeline to provide a brief history of the technology and its application. Absolute beginners are advised to start with Appendix 1, Video and Computers, and Appendix 2, Data Storage on Disc, which explain fundamental principles of video and computing to readers unfamiliar with these markets.

Rather than duplicate information freely available in other books, most of the advice and examples quoted here are drawn from observation, interviews and conferences to which the general reader would not easily have access. The appendices include a reading list to direct newcomers to other books and journals, and the text or footnotes cite the source of quotes from speeches and presentations. (All readers are advised that, where designers and publishers are quoted directly, the job title and company ascribed to them are those with which they were associated at the time of the quote; astute observers will notice that many of these luminaries have since moved to other projects and positions.)

This book has been written with respect for those who dislike all things technical; however, it is important to understand at least some basic principles, to appreciate the possibilities and the constraints inherent in the various multimedia systems. It is also important to understand the creative process through which multimedia programmes are developed. Some degree of understanding, of technical and creative issues, goes a long way toward demystifying the welter of new words and ideas in this large and rapidly-expanding market.

1

Interactive multimedia

Man's three-pound brain is the most complex form of matter in the universe. It is an organ built strictly for amusement, and amusement comes most naturally from learning – an exercise for which the brain is better built than any other element in the world.

Isaac Asimov, scientist and novelist[1]

Picture this:

- Everything in the home entertainment centre – television, video and hi-fi – combined with everything entertaining about the home computer – games, teach-yourself packages and reference material.
- Everything in a corporate training centre – overhead projectors, tape/slide shows, audio cassettes, computer-based training, corporate video, manuals, workbooks, databases, students' records and company newsletters – in one system, accessible to all yet totally secure.
- Everything in a point-of-information (POI) display – video loops, brochures, catalogues – tailored to meet each customer's individual needs, and even to process orders, monitor enquiries, and record sales leads.

The equipment which delivers all this information may be as simple as a compact disc player which plugs into the television, or as complex as a desktop video workstation in a high-tech office. It is common enough to introduce new products by describing their appearance or features. But it is not the technical specifications which will attract people to multimedia systems – or explain the concept to the wider market.

Media such as books or records are easily identified with objects which have, fundamentally, hardly changed since their inception. Multimedia is something else again. The technical features of various multimedia 'platforms' are summarized in the

next chapter, and CD-I is of course discussed in detail throughout this book. However, given the rapid rate of change in similar markets, it is likely that multimedia systems will change apace, in appearance, size and composition. Given, too, the relative indifference of most consumers to technical issues, this hardly matters.

Computer buffs and hi-fi specialists may follow technical developments with rapt attention, but most users are interested in the effects rather than the mechanics of change. Benefits, not features, will sell multimedia.

From the consumer's point of view, multimedia systems can employ virtually any combination of hardware and software, so long as the products offer value for money. Multimedia systems will not be perceived or desired for their functional specifications, but for the benefits which they offer their users.

FROM MANY MEDIA TO MULTIMEDIA

The word multimedia has already acquired diverse meanings in various technical fields. Some computer buffs use multimedia to describe the hardware which allows computer data to be sent from one machine to another. Many audio-visual specialists remember when multimedia meant presentations which combine still images from slide projectors with a soundtrack. Some software producers use the term to describe packages which combine computer-generated text and graphics on the same screen, especially if the graphics move, or there are also sound effects.

All this may be multimedia, but the word implies a great deal more than cable connections or animated graphics. Ideally, multimedia systems provide, in a single box, all the hardware and software necessary to combine still and moving pictures – including video, photographic images, computer graphics and animation – with sound, text, computer-generated data and computer programs. Equally, all the information in a multimedia programme – sound, pictures, text and data – can be recorded on a single object (typically, an optical disc).

The essence of multimedia should immediately be clear to those familiar with the various applications of computer-based technology to training, education, marketing and publishing – particularly that first successful combination of audio-visual media and computers, interactive video (IV).

Only a decade ago, all the energy of a nascent IV market was concentrated simply on persuading computers and video players to communicate, and to combine sound and pictures from an analogue videodisc or tape with text and graphics from a digital

computer. The delivery system which emerged typically combined text, graphics and computer programs from the computer's floppy disk with sound and pictures from a videodisc player. For all its teething problems, interactive video seemed to promise limitless possibilities – once a few technical problems were resolved.

However, as both designers and end-users became more familiar with this new environment, a significant gap appeared between the endless possibilities and finite achievements. As machines became more powerful, and storage media more versatile, designers and users became more confident about handling large volumes of diverse information in new and unexpected ways. Systems improved, but designers still needed *more* storage capacity, *more* processing power, and *more* control over the audio-visual elements of the programme.

Experiments with new hardware configurations variously included compact disc drives to increase storage capacity, digital video interface cards to improve versatility, modems and facsimile machines to effect long-distance communications, and even the use of satellite broadcasting to disseminate data over large areas. Clearly something much more ambitious than 'interactive video' was emerging and, with it, a new order of technical challenges and radical solutions.

Thus, the single word 'multimedia' effects in language what the technology achieves with hardware and software – it brings into one tidy package a variety of media and methods previously dispersed over several objects and disciplines.

The theory is still more advanced than the practice (for reasons explained more fully in the chapters which follow) but the striking difference between the first interactive video programmes, in the early eighties, and the first CD-I discs, only a decade later, amply illustrates how quickly technical problems are being resolved, and how much designers have learned already.

The multimedia mix

Multimedia systems draw data from many sources. Interactive video, which combines several pieces of disparate hardware, literally takes sound and video from one medium, and computer text, graphics and data from another. Even in an integrated system such as CD-I, which stores data of all kinds on a single disc, sound and pictures, text and graphics may be drawn from different parts of the recording, one after the other, and combined variously within the system as the programme unfolds.

One result of this approach on the design of the programme is that the same information, once recorded, can be used many times in different ways. One graphic

may provide the background for several scenes, in combination with a variety of foreground images, captions, sound effects, music and commentary. One sound effect may be used to enhance any number of visual images. The same musical motif may be played at regular intervals to signal breaks or transitions in the programme.

In conventional media, a sound effect or image that occurs several times during the course of the programme must be recorded as often as it is required, in the appropriate location. With multimedia systems, any data once recorded can be used any number of times. Thus, the actual storage capacity of a compact disc, or even a computer's hard disk, does not reflect the potential length of the presentation which it supports. A 30-minute videotape supports a 30-minute presentation; an interactive multimedia programme typically supports several hours of training, study or entertainment from a single disc.

As the descriptions in the next chapter illustrate, the various multimedia platforms use similar components and techniques, but apply common principles in different ways. They are more likely to share functional characteristics than technical specifications. The next sections briefly address some basic principles – interactivity, branching, transparency and navigation – which are common to all multimedia systems.

Interactivity

Most people understand interaction as a form of reciprocal communication, action and reaction. Transplant that idea from the group therapy session to a hole-in-the-wall cash dispenser or a computer-based training system, and it is easy enough to see how people interact with machines.

Machines which allow their users to make a request or select an option, and then respond logically to that action by providing information or services, are 'interactive'. The response may be as simple as providing cash on request, or as complex as staging a full-scale simulation.

The idea of interaction is usually associated with technology-based systems, but it describes virtually all our contact with machines. As operators, we give an instruction to a machine, and it reacts. However, both the operator and the machine must receive information which has some meaning for them, and which they can use. If all is going well, the machine does what the operator expects; if it does not, we might assume that the operator made a mistake, that the machine is malfunctioning, or that there is a flaw in the process.

Whether the machine is working in a factory, or providing information to a tourist, the basic principles of interaction remain the same:

- The system itself must be powerful and robust enough to respond quickly, and perform reliably, within the environment for which it was designed.
- The people who use the system – whether trained operators or casual visitors – must understand what is expected of them, and find both the information and the options which they need or expect.
- Communication between machines and their users must be direct, logical and – where users are offered some degree of choice – as versatile as possible.

In technology-based systems, interactivity can help many different users find information in a way which is useful and interesting to them personally.

The user might be playing an adventure game, looking for new products, or undertaking a training course. The interactive system typically allows users to seek information, make decisions and respond to choices. For every action which users can take, there should be a logical response from the system. The system itself may pose questions – to test users' comprehension, perhaps, or refine a request – so the interaction is often a form of dialogue.

Branching

The essence of an interactive system is its ability to respond to users' requests and decisions by finding, from the large volume of data available, specifically that information which most closely addresses users' expressed needs and interests. It does this by travelling away from a common entry point through a network of information and options to find exactly that which matches each user's needs. In computing terms, this is called 'branching', a metaphor drawn from a tree which grows from a broad central trunk into an array of separate branches which become more slender the further they reach.

The paradox in interactive systems is that the two types of information retrieval at which they excel are, first, those which move rapidly from a large body of information to a few specific facts and, second, those which build up a complex picture by providing a variety of information which illuminates different aspects of a broad topic.

In a tourist information centre, users may start with a presentation which contains everything that a visitor may want to know, and within a few moments extract a printed list of Italian restaurants within walking distance of the visitor's hotel, with a map to

show where each one is, and notes to classify them by price and ambience. In a management training programme, users may participate in a role-playing exercise, to see the probable consequences of various kinds of behaviour. A full-scale dramatization can unfold on the screen – and be replayed to explore different responses to the same situation – entirely within the privacy of the training centre. Both systems employing branching to select just that information which is appropriate to the situation at hand.

Transparency

In any presentation, the audience should be engaged by the message rather than the medium. Whether users tap a touchscreen, press a button, type on a keyboard or manipulate a mouse, the actual process of interacting with a machine should be as easy as possible. This has less to do with the available technology than the perceived skills and abilities of the target audience – a tourist would probably use a touchscreen or a keypad, while a management trainee might reasonably be expected to use a mouse or a keyboard. Some packages offer their users a choice of 'input devices' to suit the different tastes of a diverse audience.

The mechanics of interaction should not distract the user unduly, nor should users be aware of the technical processes necessary to interpret requests and choices, find data, or mix various images on the screen. The technology should be as transparent as possible – users rarely care, and hardly need to know, how the system works, so long as it acts quickly and responsively.

Navigation

The key to all this, technically and conceptually, lies in a buzzword, 'navigation'. An interactive information system, be it a children's game or an electronic encyclopedia, is world in miniature, with well-trodden highways and open seas, for which visitors need both maps and means to travel. It is the designer's job to make those excursions as many, various, simple, enjoyable and profitable as possible, for many travellers, who may undertake the journey for any number of reasons.

Of course, it is important to remember that a machine cannot hold an infinite amount of information, any more than a person can. An interactive system may store quantities of data, and offer this information to users in many ways, but it is ultimately restricted to providing the data, and offering the options, which its designers foresaw as being

appropriate for its users. They had to make informed decisions about what users might reasonably expect from the system, and even anticipate problems which users might have or cause by misinterpreting or misusing what is offered to them. No technical platform, however splendid, is immune to the inevitability of 'garbage in/garbage out'.

NEW TECHNOLOGY?

Movies and discs were effectively born in the same year, 1894, when Louis Lumière invented the cinematograph and Emile Berliner began to experiment with flat recordings for the gramophone. The next year, 1895, saw the first public film show, in Paris (and the first automobile show, in London). Electrification was proceeding apace, the X-Ray had just been invented, and Guglielmo Marconi would soon demonstrate wireless telegraphy on Salisbury Plain.

Then as now, new technology was developing rapidly in a highly competitive market. There were often quarrels in apportioning credit for achievements which drew on the work of many people. The public did not always see the connection between the new and the familiar, and regarded many new contraptions as novelties or luxury items with little practical use, real or potential. Reputable manufacturers turned down ideas which later made fortunes for other people, and sunk fortunes of their own into ideas which could not be turned into successful products.

The ultimate use of new inventions is not always obvious at the outset – the telephone, for example, enjoyed a brief career as a broadcast medium, when the 'theatrophone' relayed live performances from concert halls, theatres and the opera to subscribers in much the same way as modern cable television services.[2] As early as the 1880s, cartoonists at least imagined gramophones which could project pictures to audiences gathered in the cinema or lounging at home.[3] The appliance of science is a study quite separate from the world of invention, subject as much to market forces as technological innovation.

Of course, then as now, no one had the perfect prescience to foresee which inventions would prove practical or popular, nor to imagine how pervasive the effects of some would be. Nor was it immediately obvious how technologies would ultimately converge: the pragmatists of the 1890s hardly imagined that the products of the 1990s would include moving pictures and sound recorded on thin flat discs, hand-held players which use electricity to harness the power of light waves, and full-colour screens which combine long-distance broadcasting with personal remote control devices. Henry

Ford couldn't promise cars in any colour other than black, let alone imagine a market offering hundreds of makes and models, equipped with features including compact disc players and computer-based navigation systems.

Hindsight is a wonderful thing, and many people would be much richer now for the briefest insight into the multimedia markets of the future. But, now as then, we have to rely on informed opinion and the odd sound hunch to guess what products will be useful and popular, and where research and development will lead to ideas with practical applications.

Breaking even

It took over 30 years for the cinema to achieve synchronized sound and pictures, and another decade again to master colour. It was a good 30 years, too, from the inception of practicable broadcast television to its acceptance as a popular consumer product. Colour TV languished at the luxury end of the market for many years before securing commercial success. But the growth curves are getting shorter, and the modern market is more demanding. Ironically, perhaps, it was RCA which nursed colour TV through its lean years, and RCA which pulled the plug on the CED videodisc format within three years of its release. The pace of change is itself accelerating, and new products have now to prove themselves quickly or risk losing the support of their backers.

How long does it take for a product to be declared a success – or a failure? John Sculley of Apple Computer observed that 'It took 1000 years from its development in China for paper to be recognized as a valuable item.'[4] Fortunately for modern venture capitalists, the cycle has shortened appreciably within the last few centuries – Sculley himself reckons that advanced technology now has 'a 15-year incubation period'.

But one element of the equation that has also changed is the size of the stake: from their haziest inception, new technologies can now cost millions upon millions to research, develop, manufacture, launch and sell. (RCA reportedly spent nearly $600m on CED.) The need to recoup that investment puts great pressure on products and companies to perform well from the outset. Yet there is considerable evidence from established markets that it can take many years to achieve the magic mix of awareness, acceptance, and perceived value for money that makes a product popular, and the combination of efficient manufacturing and distribution, good marketing, and sustained development that makes it profitable. Indeed, whatever the innate qualities of the product itself, the optimum conditions for success also depend on economic and social factors which no corporate marketing team or research department can control.

Compact audio discs are undoubtedly an attractive product, but they were also launched in a market with a good deal of disposable income and a keen appetite for conspicuous consumption. Their features and benefits were easily appreciated by comparison to familiar goods such as records and cassettes, stackable hi-fi systems and remote-controlled VCRs. Their success put new life into a hardware market which was reaching saturation point – and keen consumers not only bought players, but new speakers to complement them, and even fresh CD editions of recordings which they already owned as records or tapes.

Multimedia products are more complex. Their benefits are not always perceived by direct comparison to familiar media, and only time will tell if they achieve the wide acceptance of CD audio. They are entering both consumer and corporate markets after years of worldwide recession have curbed spending for pleasure and business alike. In corporate markets, they will undoubtedly face the same barriers as all other forms of technology-based communications, from fear of change to the reluctance to invest in training or marketing of any kind.

Multimedia products will be sternly judged, nonetheless, in comparison to other audio-visual products and in competition with each other. Neither view is wholly fair to systems so different from conventional media and from one another. But it is difficult to suggest any other criteria, and the many organizations with money in this market – or money to put there – have been keenly searching for signs for some time already.

How long the first investors will hold their nerve, and how long the second wave will wait to invest, are open questions. Certainly, many of those involved with interactive video – hardware suppliers and programme-makers alike – are still underwriting that side of their business with some simpler complementary pursuit, such as conventional hardware sales, corporate video or employee communications.

It is notoriously difficult to predict which new products or technologies will ultimately prove profitable, but it is equally difficult to imagine the day when a business which is now flourishing will be unable to compete with the success of something which is now new and unproven. Black-and-white silent films were so successful that talkies and colour were regarded as dispensable novelties by many people in the film industry, and their audience, for some time after *their* first appearance.

The market for multimedia

The sharp contrast, too, between the values of software and hardware producers goes back at least to the days of silent film. Hardware markets tend to be profitable only after

some years' investment, yet a large part of their success depends on software which typically has a brief shelf-life: in the interdependence of hardware and software, a long-term market is tied to a short-term one.

Popular tastes can change critically while a film or a game is still in production, or before promoters have recouped their investment. Software production is a volatile business in any medium, with high costs up front, and uncertain returns, on products which rapidly date in both style and content.

At the same time, the shelf-life even of successful software products is tied to the market for the hardware which delivers them: over decades, popular films and audio recordings may be reprocessed several times to meet the demands of contemporary media. For products with less enduring appeal, the market of the moment represents the only chance of success.

It is best not to draw parallels directly with previous markets, but to bear in mind some of the lessons learned there. It is also advisable to look twice at most 'news' in this field. All the multimedia platforms described here were announced and discussed well before they became commercially available, and few have reached the market precisely as or when forecast. The release of many slipped by months or years, not least because the solution to one problem is often the root of another, and because external forces – particularly, changes in technical standards – may impose demands not foreseen in the original specification.

None of this necessarily diminishes the worth of the product – if anything, multimedia systems are being launched at a much higher level of functionality than comparable products in the nascent computer or video markets. Nonetheless, slippage on the release date, and vagaries on the technical specification do tend to make the waiting market nervous – and to excite the attentions of the trade press, who have nothing else to discuss until the product is actually released.

Many of the products that missed the first target have proved worth the wait; some, perhaps, should have held back until they had more to offer. It is a difficult decision for any developer, to choose between *sooner* and *better*, when there is a gap of months or years between the two, and market shares to be won or lost betimes. It is often easier to upgrade a product which already has a share of the market, than to introduce an entirely new product (whatever its merits) to a market which is already committed to other, incompatible platforms.

The classic advice is usually to look for the second wave: to exploit opportunities created by the research and development, marketing and sales, initiated by the first investors in a new market. But spotting the break between the first and second waves

is tricky. It's often safer, if less lucrative, to wait until the market settles into the easy motion of the third wave, where the gains are fewer but the risks are less.

In many sectors, market research can help new investors. Unfortunately, there is relatively little published research even in the market for interactive video, let alone multimedia platforms, and what there is tends to be highly speculative, and based on opinion and projections rather than sales figures or demonstrable results. The advice of those with practical experience tends to encourage a medium to long-term view – and firmly to discourage the get-rich-quick theme.

Much of the ground for multimedia systems has been broken by computers and home entertainment products, and even by interactive video, so this market may be more ripe for exploitation than most. Multimedia systems address many of the shortcomings of conventional media, in terms which software producers and programme-makers can immediately understand. Hardware alone will not sell many systems but, in the hands of good designers and energetic publishers, multimedia products can offer consumers and corporate markets something genuinely new and compelling. The prospects for multimedia publishing are discussed again in the chapters which follow.

Notes

1 Isaac Asimov addressing the Second Annual Conference on Interactive Entertainment, New York City, 3 October–1 November 1989.
2 George Painter, *Marcel Proust* (Penguin, 1983) p. 487.
3 Erik Barnouw, *The Tube of Plenty* (Oxford University Press, 1975), pp. 3–7.
4 John Sculley, Apple Computer, speaking at Microsoft's Third International Conference on CD-ROM, Seattle, Washington, 1–3 March 1988.

2

Multimedia platforms

This chapter describes the principal uses of compact disc technology, and the application of LaserDiscs and CD within various multimedia platforms:

- Compact Disc-Digital Audio (CD-DA)
- Compact Disc Plus Graphics (CD+G)
- Compact Disc-Read Only Memory (CD-ROM)
- LaserDisc and Compact Disc-Video (CD-V)
- LaserDisc-Read Only Memory (LD-ROM)
- Interactive Video (IV)
- Photo Compact Disc (Photo CD)
- Digital Video Interactive (DVI) technology
- Desktop Video (DTV)
- Commodore Dynamic Total Vision (CDTV)
- CD-ROM eXtended Architecture (CD-ROM XA)
- Compact Disc-Interactive (CD-I)
- Electronic books
- Recordable and erasable discs

The various systems are described comparatively to indicate, where applicable:

- Storage capacity
- Video, graphics and audio capabilities
- Typical delivery systems
- Prevailing technical standards

This discussion also explains the principles behind genlock and overlay cards, digital video, compression and decompression, and describes the work of the International

Standards Organization (ISO) and others in establishing technical standards for the compression of still and moving images.

A number of the technical terms used here are explained in Appendices 1 and 2, as well as in the Glossary (Appendix 3). Readers who are not fully conversant with the basic concepts or technical language of video, computers, or optical disc systems, are advised to read those appendices now. Those who are familiar with these markets, but who have not considered the use of conventional technology in multimedia, might also skim the appendices for specific information about multimedia applications.

MULTIMEDIA SYSTEMS

The components of the various multimedia platforms are, initially, very similar: computing power of some kind, and a storage medium which is usually some form of disc. The individual platforms differ substantially in the ways in which they adapt these basic elements to a common end.

Multimedia systems typically store the various components of the programme separately, to mix and match in different ways. This requires a combination of retrieval and processing power, to identify the components in any one sequence and combine them seamlessly as the presentation unfolds. Thus:

- A multimedia system must be able to store a sufficient quantity and variety of information to record sound and pictures, text and graphics, data and control programs.
- It must also be able to move all this information efficiently from the storage medium (for example, a CD-I disc) to the appropriate parts of the delivery system (such as a television, speakers or other 'output devices').

Most multimedia systems accomplish these complementary functions through a combination of production techniques and technical features. Most employ some form of data compression and decompression to store and process complex information such as video pictures as economically as possible. Most also employ shortcuts, such as storing small quantities of data which might be used several times in succession (such as sound effects) in the processor's own temporary memory, for easy access without extra retrieval time or processing power.

Thus, the technical criteria by which multimedia platforms may be evaluated and compared should include:

- The quantity and variety of data which the storage device can hold.
- The quality of the sound and pictures which the system itself delivers.
- The facility with which the system assembles and processes all these data.

The several platforms described here offer a range of features which could appeal variously to different market sectors. Some are competing for a single audience, but several are complementary, and the market mix, when all are commercially viable, may well apportion some sectors to each.

The descriptions of the various platforms are set out to suggest similarities and identify differences, which should in turn illustrate the potential of each to markets of different kinds (see Fig. 2.1). Chapter 3, Multimedia Titles, cites examples of the ways in which these platforms are already being used, for consumer products and in professional fields such as marketing, training and education.

COMPACT DISC-DIGITAL AUDIO (CD-DA)

CD-DA (or simply CD-A) is the original compact disc, and the one CD product now widely recognized by consumers. The emergence of computer games on other CD formats is beginning to change that perception, in one important niche market at least, but for most people, 'CD' still means high-quality sound.

CD-DA was initially developed by Philips, but other manufacturers (particularly, Sony) helped to create an international standard for both discs and players. CD-DA was launched, in 1982, as the first in a series of upwardly compatible products which now includes CD-ROM, CD-ROM XA and CD-I. Thus, CD-DA's functional specification, the *Red Book*, is the model on which the CD-ROM's *Yellow Book*, CD-I's *Green Book*, and the *Orange Book* for 'CD-R' write-once recordable discs such as Photo CD are based. All compact disc formats have certain features in common: these are described in more detail in Chapter 6, CD-I Discs and Drives, but the main points should become apparent here.

CD-DA storage capacity

The principles of audio data recording and storage on a compact disc are explained in Appendix 2. The essence of the system is the conversion of fluctuating analogue data from the world around us into concise digital code which can be efficiently stored, retrieved and reprocessed through a form of computing technology. CD-DA employs

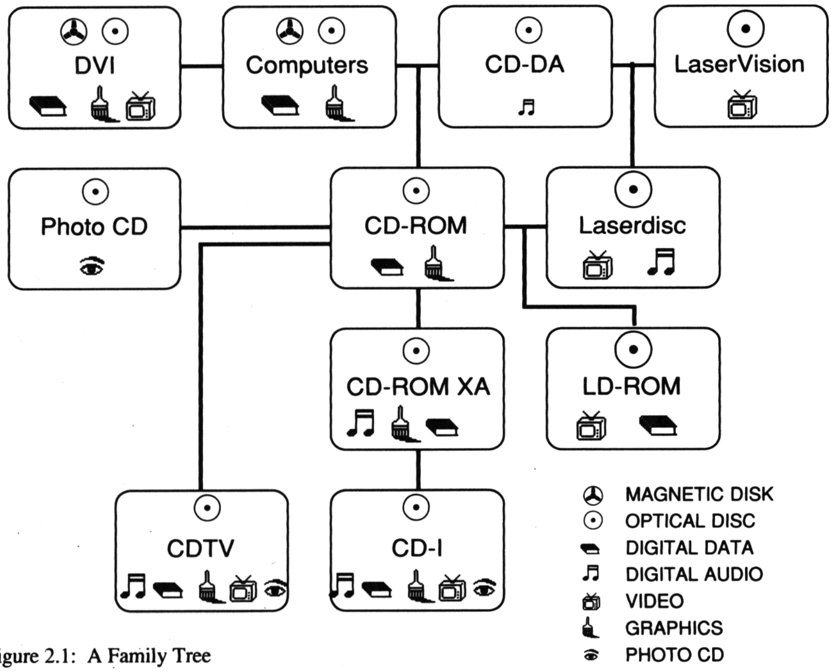

Figure 2.1: A Family Tree

the extremely high fidelity of the encoding system known as Pulse Code Modulation (PCM), which occupies the system's full bandwidth – that is, virtually all of the storage space on the disc, and the processing capacity of the player – to produce audio recordings of the highest possible quality.

This hardly makes the compact audio disc a multimedia product. However, seeing the shape of things to come, some music publishers are now producing discs which can be played on any CD system, but offer extra features to those who upgrade to players which can display the text and graphics recorded with the audio data on the disc. This is the first step on the road to multimedia.

A conventional CD-DA disc has some room to spare even if it contains over an hour's worth of music. A compact audio disc can hold around 72 minutes of high-quality digital sound on two (stereo) tracks. Other compact disc formats need storage space for the control programs which give CDs their versatility; however, the relatively simple data on audio discs are easily retrieved and processed, so virtually the whole disc is available for the recording itself.

For the most part, instant access to any one track on the disc satisfies the average user's demands on a CD audio system. However, most CD-DA players are also

programmable – that is, listeners can pick out their favourite tracks, and arrange the order in which they are played. With CD-DA, if you disagree with the conductor's interpretation of a contested score, you can program your player to put the disputed aria where you think it belongs. Alternatively, you can skip the song you just can't stand. The control program resides in the CD player's own memory, so the disc itself remains untouched for future use.

Even with this interactive programming capability, there is still room on a CD-DA disc for text and graphics, the key to multimedia. Of course, these are neither so numerous nor impressive as those of more fully integrated systems, but they suffice to fill the screen with information and pictures while music plays from the disc. There is enough space on a CD-DA disc to carry the notes and lyrics which now accompany many recordings as plump little booklets of very fine type.

CD-DA delivery systems

CD-DA, like CD-I, comes to the consumer as a single box, of a shape and size similar to a video player or one component in a stackable hi-fi system. The player is attached to the hi-fi or speakers, and the cord to the power point is usually the only other connection necessary, so the whole system can be set up within minutes.

The CD-DA player may be controlled from the hi-fi, from its own built-in function keys, or with a hand-held controller, which is modelled on those of television and video systems. What happens inside the box is of little interest to most listeners, and many are content simply to play music, and only occasionally use the remote control pad, without ever venturing into features such as customized control programs.

These are the principles on which most platforms for the consumer market are based: a single attractive box, easily connected to equipment already in the home, a remote control unit not dissimilar to others now in use, and instant gratification for the most unadventurous user, together with extra features for those willing to experiment.

COMPACT DISC PLUS GRAPHICS (CD+G)

The term 'CD+G' describes applications which are primarily devoted to sound or text, but which also contain graphics. Specifically, the term describes discs which employ the six spare sub-channels on a CD-DA audio disc to store digitally-encoded graphics and text. (These are explained more fully in Chapter 6, CD-I Discs and Drives.)

A special range of CD audio players can process this additional information and deliver it to an ordinary television, as can some multimedia platforms. JVC began to distribute these players to selected American markets in the summer of 1989 (when the $500 price tag put CD+G in the same range as the Pioneer LaserDisc players being launched in the same market at the same time).

The term CD+G describes audio discs which combine a complete CD-DA audio recording with additional material for those who have players which can decode it. This typically includes liner notes, credits, cast lists, lyrics or libretti, discographies, illustrated scrapbooks, interviews with the artists, or other background material. CD+G discs can also provide a 'preview' of the disc itself, or others in the same series, which can be used in shops and seen at home, rather like the trailers or advertising included on some videotapes.

The attraction of CD+G for developers is that the format uses relatively simple equipment to support presentations which are unlike anything else yet known to consumers. By comparison to other multimedia products, the visual effects may be simple if not crude, but they are undoubtedly novel by comparison to any other form of audio disc. Equally, any form of screen presentation could improve on the tiny liner notes to which CD formats are effectively restricted. As technologies converge, the options increase for developers and consumers alike.

COMPACT DISC-READ ONLY MEMORY (CD-ROM)

CD-ROM was developed as a high-volume data storage medium for computer-based systems. The format was released a few years after CD-DA, in 1985, to professional rather than consumer markets. Initially, CD-ROM discs only held text or data, and acted as capacious peripheral storage devices and databases. Latterly, they have also come to store graphics and audio. However, this format was not designed to handle a variety of data streaming rapidly through the system, so CD-ROM tends to complement text with sound and pictures, rather than integrate all three in dynamic displays.

CD-ROM storage capacity

Like other compact discs, a CD-ROM disc typically holds, in computing terms, about 650MB of data (which some producers can now nudge up to 675MB). A single disc could carry some 250 000 pages of textual information – as much as 1500 floppy disks.

However, without logical and efficient retrieval systems, this would be the technological equivalent of a library in which all the books were bound in identical blank covers and randomly arranged on unmarked carousels.

In practice, a good portion of the disc's capacity is devoted to the various indexes and retrieval programs needed to control such a large volume of data. As much as half the space on a CD-ROM disc may be devoted to indexes which facilitate access to the information on the other half. But this is the product's special attraction: CD-ROM combines a small, light, robust storage device with the capacity to hold not only large quantities of pure data, but also the many retrieval programs which allow users to make versatile use of that information. It is easy to appreciate the value of data alone, but it is important also to understand the complementary value of efficient retrieval systems.

Thus, the capacity of a CD-ROM disc to store text, data and images depends on a number of technical factors, including both the quality of the sound and pictures, and the complexity of the data and retrieval programs. The sample of electronic publications cited in Chapter 3, Multimedia Titles, demonstrates how variously a CD-ROM disc can be employed: one, for example – the *Hutchinson Electronic Encyclopedia*, released in 1990 by Attica Cybernetics and Random Century – features 25 000 articles, 7000 biographies, and 250 time charts.

CD-ROM graphics and sound

The main obstacle to storing pictures on CD-ROM was, initially, the sheer volume of data which a complex computer graphic or photographic image may require. With new compression techniques, the amount of information which needs to be stored on disc can be dramatically reduced. Thus, a CD-ROM can now typically hold over 10 000 images of various kinds, as well as text and sound. A new range of desktop video tools can even present a simple form of moving pictures from CD-ROM. The actual number of images on any one disc of course depends on the complexity of the data: detailed photographic images with subtle colours demand more storage space and processing power than simple drawings.

CD-ROM can also, of course, store audio recordings. It is neither practical nor necessary to use the high-quality stereo of CD-DA in a typical CD-ROM application, but even at lower levels of quality, the disc can store many hours' worth of speech, music or sound effects.

Altogether, a CD-ROM disc can easily hold an encyclopedia, the Bible, or the *Complete Oxford English Dictionary* – footnotes, appendices and all – and still provide

sound and pictures to enhance the text and make its meaning more clear and relevant. This is CD's equivalent of an illustrated reference book, and the ideal combination of media for CD-ROM. The problem with using CD-ROM as a more ambitious multimedia device arises when any greater demand is made on the flow of different kinds of information from the disc through the delivery system.

CD-ROM and multimedia

The potential of CD-ROM as a multimedia device is limited by the very technical functions which make this platform so efficient in the storage and delivery of conventional databases.

CD-ROM systems deliver text, graphics and sound separately, and relatively slowly by comparison to other audio-visual platforms or computer disks. CD-ROM also encodes data so that all audio-visual information must pass through the drive's central processing unit (CPU) before being sent on to the appropriate audio or video processor. This is partly due to the functionality of the disc and drive, and partly to the actual organization and retrieval of data on the disc – all of which is explained in more detail in Chapter 6, CD-I Discs and Drives – but the ultimate effect is to render CD-ROM systems slow by comparison to multimedia platforms such as CD-I, or other data storage media such as magnetic disks.

CD-ROM is equal to the demands of an encyclopedia with a few pictures, but not powerful or fast enough to supply the variety of data required by true multimedia, which is addressed by platforms such as desktop video, DVI technology, CD-ROM XA and CD-I, all of which are explained below. Yet even with limited audio-visual capabilities, the CD-ROM versions of large databases offer reference tools unlike any available in conventional media.

Features such as 'keyword searches' allow instant access to any one phrase among hundreds or thousands in the database. Books or libraries depend on the indexing and cataloguing skills of intermediaries such as editors and librarians to define the ways in which users can retrieve information. Databases with 'free text' search facilities allow users to choose their own terms, and design hierarchical structures for the information they value.

Naturally, such retrieval programs need routines to refine the search: the references to 'love' alone, for example, fill seven pages of fine print in a conventional concordance to the works of Shakespeare. A typical program may find the information which meets the user's first criteria, and then provide details to direct the next stage in the search –

references to 'I love' perhaps, or 'love you'. All the references to a given surname, for example, might also include forenames or dates. CD-ROM and CD-I offer these features to consumer markets in reference works such as the Grolier *Electronic Encyclopedia* and *Multimedia Encyclopedia.*

Thus, while the contents of an entire book shelf can easily be subsumed in the CD-ROM disc's 650MB, the remaining storage space is fully exploited in making good use of this information. Similar principles of course apply to all other applications of compact discs to interactive information systems: the challenge to the designer is to provide the right retrieval systems for the data on the disc, the delivery system itself and the needs of its users.

CD-ROM delivery systems

CD-ROM discs were designed to provide peripheral storage for computer-based systems. So the CD-ROM player or drive simply holds the disc and directs the data which it contains into an adjacent computer system (which typically includes a monitor, keyboard, mouse and, often, speakers or headphones as well).

However, the CD-ROM drive can also be built into the computer, just like a floppy disk drive. A CD-ROM drive features in the minimum specification for personal computer systems drawn up by the Multimedia PC group (described below). In Japan, the Fujitsu FM Towns home computer was launched with a built-in CD-ROM drive in 1989. This stimulated the competition, and a new range of home computers and games consoles now feature low-cost CD-ROM drives. This has been done largely without alerting consumers to the high-tech implications of CD-ROM. However, the functionality of FM Towns is such that Fujitsu even sponsor competitions for amateur software developers.

A CD-ROM drive can also play CD-DA audio discs, thus bringing the computer closer to a true multimedia platform, and to home entertainment systems, too.

CD-ROM standards

The CD-ROM disc is a medium on which data can be encoded in many different ways. To decode the information stored there, the computer which reads the disc must be able to understand how it is arranged, and what its various codes mean. The singular problem with CD-ROM has been the lack of industry standards to dictate the way in which data are recorded and retrieved.

The *Yellow Book*, produced by Philips and Sony, defines the organization of data and sector structure of a CD-ROM disc, but does not define specific structure of the files, directories and paths in which those data are stored. These issues were addressed by an *ad hoc* committee of hardware, software and publishing interests known as the High Sierra group (for the hotel on Lake Tahoe where they first met, in 1985). Their recommendations influenced the International Standards Organization's ISO 9660.

However, even ISO 9660 does not address every aspect of a CD-ROM application. It defines the external characteristics of the 'blocks' in which data are stored on the disc (that is, their file structure – including 'header data' such as name, originator, copyright and date – directory structure, and the hierarchical paths along which directories are arranged). It does not define the contents of these blocks, nor a means of retrieving those data. Metaphorically, then, all the books in this library look exactly alike, but they may contain absolutely anything, and there is no uniform way to compile a catalogue.

CD-ROM is not a system, as CD-I is, with comprehensive functional specifications to direct every aspect of its operation. CD-ROM discs are no more universally compatible than floppy disks are: any disc may fit the drive, but the operating system at the heart of the computer cannot necessarily interpret the data it finds there.

This is a reflection of a problem within the computer industry itself, for although the widespread use of IBM and compatible PC's has established a *de facto* standard for a large market, other products have their share, and the many operating systems and technical specifications in the market as a whole mean that few products more complex than mouse mats are universal. It is often possible to transfer data in some form from one computer platform to another, so a report composed on an Amstrad WP does not necessarily have to be re-typed for editing on an Apple Macintosh or IBM PC. However, each of these three alone requires different software to run the same spreadsheet or word processing package.

This problem is being addressed, of course. The 16 companies in the Rock Ridge group first met in July 1990, extending High Sierra's geographical metaphor as well as the principle of technical development through *ad hoc* committees. They submitted two related proposals for extensions to the CD-ROM specification to the US National Institute of Standards and Technology in the spring of 1991. Institutes move cautiously, necessarily so, but the inconsistencies in the CD-ROM format should ultimately be resolved.

However, the transition from mixed media on CD-ROM to interactive multimedia was not based on compact disc alone for, as CD stormed the consumer market, discs of another kind were faring rather differently elsewhere.

LASERDISCS: LASERVISION AND CD-V (CD-VIDEO)

To understand some aspects of the market for interactive multimedia, it is useful to look first at something structurally similar and critically different: LaserDisc. The history of the videodisc, and the emergence of the reflective optical videodisc – LaserDisc – which is now the *de facto* standard, is explained in Appendix 2.

The 30cm/12 inch reflective optical videodisc, which records analogue audio-visual data, has been known by several names. It was first described as a VLP (Video Long Play), with emphasis on its similarity to the long-playing vinyl record. When the emphasis shifted, in the early eighties, LaserVision was the term officially associated with Philips' products, while Pioneer registered LaserDisc as their trademark. In November 1989, Pioneer released 'LaserDisc' to the market at large, and in February 1990, Philips officially adopted the term for their full range of videodisc products.

The term CD-Video (CD-V) was launched by Philips in the summer of 1987, to describe products for the consumer market. CD-V offered analogue video and digital audio on discs of three sizes: 12cm/4.75 inch singles (with six minutes of video and 20 of audio), 30cm/12 inch LP's (with an hour of video and sound), and a mid-range 20cm/8 inch format with 20 minutes of video. All three could be played on a 'combi-player' together with all-analogue LaserVision discs, and CD-DA audio discs. (Even as CD-I itself was being launched, Pioneer announced plans for a CD-DA, CD-I and LaserVision combi-player.)

The combi-player caught on so well that the player dedicated to CD-V 'singles' was never released, and CD-V itself failed to establish an identity. So, in the spring of 1990, CD-V changed to LaserDisc. In practice, of course, many people still use the terms LaserVision and LaserDisc interchangeably.

LaserDisc graphics and video

Videodiscs are primarily analogue storage media, designed to record video signals compatible with the national broadcast standards of the country in which the player is used. Thus, while they are less versatile than CD-based formats, they also offer a larger number and higher quality of still and moving pictures than any other video-based platform so far. (For more information on these standards – NTSC, PAL and SECAM – see Appendix I; for an explanation of CLV and CAV, see Appendix 2.)

- A 30cm/12 inch 'long play' CLV disc typically holds about 86 000 frames per side – enough for some 48 minutes (NTSC) or nearly an hour (PAL/SECAM) of linear

moving footage on each side. CLV assigns a uniform length to every frame, and varies the rate of spin from the centre to the outer edge of the disc, depending on how many frames have to be read in one rotation.

- A 30cm/12 inch 'active play' CAV disc holds about 55 000 frames per side – enough for 30 minutes (NTSC) or 36 minutes (PAL/SECAM) moving footage per side. CAV discs assign one frame per rotation (shorter near the centre, longer near the edge), and spin at a constant rate of 1800 rpm (NTSC) or 1500 rpm (PAL) – the key to instant frame-accurate random access.
- Either format can carry video, computer graphics, or visual material from other media (such as moving footage converted from film, or still images recorded from paper). All this material must be transferred from its source medium to a master videotape before the disc is pressed.
- Moving footage shot and recorded at standard speeds can be manipulated by a hand-held controller, or a computer program, to play backward and forward, faster or slower, and even frame-by-frame ('step frame').

LaserDiscs reward the conscientious designer with high-quality video displays which resist the wear-and-tear of time and constant use. The stages in production of a LaserDisc for interactive video are described in Chapter 9, Stages in Production, and compared there to the production of CD-I programmes.

LaserDisc audio

LaserDiscs have two audio channels, which can be recorded together to produce stereo, or separately to extend the audio storage capacity of the disc. LaserDiscs (unlike some other videodisc formats) can combine analogue video with digital audio. The extra storage space in the audio tracks can also store computer-generated text, graphics and control programs.

LaserDisc delivery systems

As the brief history of LaserVision and CD-V above suggests, consumers now have a choice of dedicated LaserDisc players or combi-players (which typically take a range of disc sizes, and play both video and audio discs). Players which take only videodiscs usually now bear the LaserDisc logo, and those which also play CD-DA audio discs also bear the CD logo. The consumer player connects to the television as easily as a CD-DA player connects to the hi-fi, and requires only the TV's screen and speakers to

deliver sound and pictures (although connection of the audio channels to the hi-fi can improve the delivery of music and soundtracks).

There are also LaserDisc players for the professional market. Like professional-quality videotape players, they are more robust than consumer models, to support long hours of use in training centres, point-of-sale displays or exhibitions. They also have more features to support the integration of the videodisc player into a computer-based delivery system for interactive video, described below.

LASERDISC-READ ONLY MEMORY (LD-ROM)

A technology combining LaserDisc images with digital data emerged in LaserDisc-Read Only Memory, which Pioneer announced at Japan's first International Conference on Multimedia in October 1989, and demonstrated there a year later.

The earlier LV-ROM (LaserVision-Read Only Memory) was first developed in the UK by Philips for the Domesday Project, which sought to produce a high-tech multimedia survey of Britain on the 900th anniversary of William the Conqueror's original inventory. The Domesday format combined analogue audio-visual material with digital data on a 30cm/12 inch disc which required a dedicated Advanced Interactive Video (AIV) delivery system. Only a handful of other programmes were developed for the format, and although British schools snapped up the players when they were heavily discounted at the end of the venture, the real lesson in LV-ROM was directed at the developers.

Another portmanteau format surfaced at an American conference in June 1990. The prototype, code-named Magilla, was a modified combi-player with a 'black box' which provided enough processing power to support features such as multiple audio tracks and interleaving. A commercial version was promised ...[1]

INTERACTIVE VIDEO (IV)

To grasp the possibilities afforded by the current generation of multimedia products, it is useful to consider how 'interactive multimedia' evolved from 'interactive video'.

Interactive video combines the processing power of a computer with the audio-visual resources of a video tape or disc. Enthusiasts had been playing with the idea for decades – even trying to control film projectors with mainframe computers – but the

idea only became technically viable in the late seventies. Over the course of that decade, the development of the personal computer, and a new range of video disc and tape products, provided the necessary tools to integrate audio-visual media into computer-based systems.

A typical IV package combines video pictures, computer graphics, text and sound in a presentation which can be as flexible and responsive as a well-designed computer program, and as engaging and informative as a well-made television documentary. (IV can, of course, also be as frustrating as a bad computer program, or as awkward as amateur video. It is always important to remember that any delivery system only does what is asked of it, and the responsibility for style and content, in any medium, ultimately rests with the programme-maker.)

In an IV system, sound and pictures are usually taken from a 30cm/12 inch videodisc, while text, computer graphics and control programs are drawn separately from a computer disk. The principles behind this are explained in Appendix 2; the critical points to remember are that IV systems present sound and pictures from several sources, and that they tend to use a lot of disparate hardware and software to do this.

Interactive video delivery systems

Basic LaserDisc players for the consumer market are hardly more interactive than a videotape player or CD-DA system. Users can control the forward and backward motion of the video recording, and sometimes enter simple commands through the keypad, but interactivity is limited to what the Nebraska Videodisc Design/Production Group in their five-point scale characterized as Level 0 (no interactivity) or Level 1 (elementary interactivity).

Level 2 in the Nebraska Scale describes a videodisc player with enough power to run interactive programs under the control of its own built-in microprocessor. With a monitor for the display, and touchscreen, keypad or similar device for users' input, some professional interactive systems have used no more equipment than this for successful applications in training, marketing and education.

Level 3 describes a system which combines a videodisc player with a computer and associated hardware and software to support full interactivity. This is the level at which most IV systems now work. Level 4 is the subject of some debate, but usually describes a system which includes large-volume multimedia storage devices such as compact discs. One pundit has described Level 5 as an interactive video application that makes money.[2]

In professional applications, a (Level 3) interactive video delivery system typically comprises:

- *Processing power*, usually in the form of a computer, but sometimes also a microprocessor within the videodisc player itself.
- *At least one audio-visual storage medium*, and its drive or player – usually a LaserDisc, but sometimes videotape or even a compact disc of some form.
- *A monitor,* which can usually mix conventional audio and video signals from a video tape or disc with signals from the computer which supplies separate text and graphics; sometimes, different monitors are used to display video and computer-generated signals on separate, adjacent screens.
- *At least one input device*, typically, the computer's keyboard and/or mouse, a touch-sensitive screen on the monitor, customized keys built into a housing, or on a separate keypad.
- *Auxiliary hardware*, such as a CD-ROM drive for extra data storage, a printer of some kind (usually, a dot matrix printer for small receipts or slips, or laser printer for full-page print-outs).
- *Storage media*, usually in the form of a LaserDisc or videotape for audio-visual data, and one or more floppy disks to provide control programs and computer-generated text and graphics. (Computer data may be transferred to the computer's hard disk, to dispense with the need for floppy disks, or may even be stored on special devices such as EPROM chips or 'smart cards'.)
- *Cards or boards* inside the computer, and cables and accessories between these various machines, to effect rapid two-way communication throughout the system, and to combine analogue video and digital computer signals for display together on one screen.

In an 'integrated' workstation or, more typically, in marketing or public information systems, some form of purpose-built housing conceals the hardware, leaving only the screen and input devices exposed to users.

If this sounds like a lot of kit – it often is. However, with judicious design, it is possible to produce a portable (or at least 'luggable') IV system with minimal cabling. With good system and housing design, it is also possible to present the whole package as an attractive and user-friendly information system.

Nonetheless, the attractions of multimedia systems with 'one box, one cable, one plug' are manifest to anyone who has struggled to dismantle, pack, ship, unpack and reconstruct IV systems for use at distant exhibitions or training centres – or who has

ever faced a mass of plastic spaghetti, looking for the single loose connection which has paralysed the whole system.

Interactive video standards

In interactive video, there is no international standard for the analogue video source (which can be NTSC, PAL or SECAM), nor for the combination of software and cards to make this disparate combination of hardware interactive. Thus, IV material cannot necessarily be exchanged over national borders, nor even between incompatible delivery systems in the same room.

The majority of published software in any one country tends to run on the national *de facto* standard (which is usually an IBM-compatible PC, a LaserDisc player, and some combination of overlay card and system software). The basic elements – the PC, player, monitor and input devices – are largely interchangeable: the critical difference lies in the choice of add-on boards and software to effect communication between the computer and video displays.

In the UK, VideoLogic established a *de facto* standard with their range of IVA (Interactive Video Adaptor) cards and MIC (Multimedia Interactive Control) system software while, in the US, IBM's range of InfoWindow delivery systems and products won a large share of the interactive video market. However, several other cards from other manufacturers provide similar facilities, and some excellent packages have been developed on non-standard hardware. Older systems often need upgrades to run newer software, so *caveat emptor* is still salient advice here.

Both hardware and software suppliers appreciate the effect of incompatibility on a nervous market, and there have been initiatives to establish international standards for IV systems, notably by the American Interactive Multimedia Association (IMA), which started life as the Interactive Video Industry Association (IVIA). They published their first *Recommended Practices for Interactive Video Portability* in the autumn of 1990, and are active in the pursuit and establishment of industry-wide standards.

The experience of the IV market demonstrated the need for standards only too clearly, and the newest platforms have addressed standardization as a fundamental issue: CD-I, by defining international standards from the outset, and desktop video by promoting a *de facto* standard before a significant number of non-standard systems could reach the nascent market.

FROM ANALOGUE TO DIGITAL

The main obstacle in the short journey from LaserVision to interactive video lay in the difficulty of combining analogue audio-visual signals from the videodisc with digitally-encoded text, graphics and data from the computer.

One solution was a range of 'genlock' and overlay cards which combined these two sets of signals by locking them together and effectively laying the computer-generated images over the video pictures. The alternative actually converts the analogue signals to digital data, so that they can be processed with the same versatility as computer-generated graphics.

Analogue pictures, designed to accommodate the demands of broadcast television, split every frame of video into two complementary fields, which are processed separately and interlaced on the screen. This works well enough when viewers are sitting some distance from the television, less well where users directly in front of the screen may be irritated by *virtually* imperceptible 'flicker'. In analogue systems, too, special effects must be prepared and recorded in an editing suite, as the audio-visual data cannot be manipulated in the delivery system.

Digital images which are not interlaced are more stable and easier to watch at close range. Digitization generally improves the quality of the picture on the screen, making it sharper and brighter, and also allows still and moving images from a video source to be manipulated as easily as any other digital data.

New digital techniques can be used with older LaserVision discs. In the UK, for example, the combination of VideoLogic's DVA 4000 (Digital Video Adaptor) with industry-standard Microsoft Windows 3.0 software allowed the Histopathology Department at Leicester Royal Infirmary to design a new medical training programme around a videodisc pressed some years earlier. In the new version, images from the disc can be displayed in windows on the screen, even side by side for direct comparison, and analysed at different levels of magnification. Pictures of real cells from the disc are combined with computer text and graphics to teach students how to recognize and diagnose abnormal patterns. Regular tests and exercises throughout the course can employ visual as well as textual questions – an obvious advantage in a diagnostic teaching programme.

With digital overlay cards, this process of turning analogue data to digital is accomplished in 'real time' – that is, as the signals flow from the disc, tape or even a television or camera. The video may be taken from a recorded, live or broadcast signal. It is not permanently affected by the digitization, but remains analogue at source –

rather as a photocopy might be annotated and discarded without leaving a mark on the original document.

Many products facilitate communication between analogue and digital, video and computers. Some combine video and computer data for display on the screen, in analogue or digital form, others convert the output of computers or IV systems for display on conventional TVs, monitors or video projectors, for recording on a variety of videotape formats, or integration into desktop video presentations.

The obvious alternative to all this is, of course, the fully digitized system, in which all audio-visual data are recorded and processed as digital signals. However, to convert the world's broadcast television services to an all-digital environment would require massive investment from the industry itself, replacement of more than a billion TV sets worldwide, and agreements on international standards which, to judge by present conflicts over satellite broadcasting or high-definition television, could be a greater obstacle than all the capital costs put together.

Digital video also puts great demands on systems such as computers and compact discs, which were not originally designed to handle large volumes of complex visual information (as Appendix I explains). The multimedia platforms described here address the challenge of storage space and processing power in various ways.

COMPRESSION AND DECOMPRESSION

As the notes in Appendix I explain in more detail, a conventional video signal, encoded as a series of RGB computer graphics, could require up to 600KB of storage space for every frame of video (of which there are usually 25 or 30 in every second's worth of moving pictures). In any multimedia system, this in turn demands a transfer rate of 15MB per second to keep all these data flowing from the disc through the central processing unit to the screen. Thus, the same CD that holds 250 000 pages of text could not store one minute's worth of video, nor process so much information quickly enough to present it to the screen and speakers. One manufacturer has described the challenge facing multimedia developers as 'sending a fire-hose full of water through a straw'.[3]

The key is 'compression'. Compression reduces the volume of information in the audio-visual signal so that it requires less storage space and less processing power. This must be done logically and consistently, not only to ensure that the compression system works efficiently, but also to establish standards across a variety of hardware platforms and application programs. Standards obviate the need for every individual project or

platform to develop its own criteria, and allow information to be exchanged freely across any number of products and systems.

Compression codes are typically expressed as mathematical formulae called algorithms: a compression code, like any other formula, follows a strict pattern to process all data uniformly. The complement of compression codes are, of course, the decompression codes which reconstitute the data before they are displayed again. Within the logic of the algorithm, the decompression deduces, from the compressed data available, what information is necessary to complete the signal and reconstruct a coherent stream of sound and pictures.

Sampling techniques

All digital audio systems employ sampling techniques to convert the continuous analogue audio signals of the real world into a series of discrete digital codes (as Appendix I explains). Large and frequent samples capture much of the signal and produce recordings of extremely high fidelity. Where the samples are smaller or less frequent, the quality of the reproduction is lower – as are the demands on both storage and processing capabilities. Stereo music recordings require large and frequent samples, but speech and sound effects can be adequately reproduced with less data.

When digitized audio or video is replayed, as a rapid series of discrete samples, there is still so much information for the brain to process, that we cannot detect the minute gaps between these many closely graduated samples. A similar sleight, of course, disguises the fact that even conventional moving pictures are only a series of static images (effectively, samples) run very quickly together.

Many compression techniques take this principle a step farther, by removing data from the stream at regular intervals, to reduce the total volume recorded. When the signal is reconstituted, the missing information may be replaced by data which are artificially-generated to lie half-way between the genuine samples, or which simply duplicate the genuine samples to increase the density of information being supplied. Either technique is enough to present the eye, ear and mind with enough information to create the impression of coherent sound and pictures.

Compression techniques

In audio recordings, data can simply be removed at regular intervals to compress the total volume of information required. Video signals offer other opportunities for

compression. Data in video and computer graphics are both displayed (albeit in different ways) in lines across the screen. Computer-based images are conveniently divided into single units called pixels (a contraction of 'picture elements'). The resolution, or visual quality, of an image is expressed in video by the number of lines per screen, and in computing, by pixels. The more lines or pixels, the greater the density of data provided, and the higher the resolution, or quality, of the image displayed.

Most compression algorithms look for patterns in the video signal. Where a large block of colour appears, for example, the colour-coding information may be the same along the entire length of one line, or a good deal of it at least. A compression signal, therefore, stores only the data necessary to establish the colour at the start of the line, and note any changes subsequently. (This is the principle behind CD-I's Run-Length Encoding technique, which literally encodes the length for which each colour runs along each line.)

Similarly, the subtle graduation between the 25 or 30 individual frames in every second's worth of video means that the image changes very little from one frame to the next within the same scene. Just watch the television screen critically to observe how movement at any one time is often concentrated in one area – the face of the person who is speaking, for example, or a figure quickly moving in the centre of the screen against a more slowly changing background.

Compression systems which employ 'frame differencing' techniques may record all the data only in the first frame of a sequence, and then merely note the changes which distinguish one frame from the next. When the information is reconstituted, the missing data are supplied by comparing the information at the start of the signal with the modifications which follow. Many systems make decompression simpler by recording all the data not only from the first frame, but from reference frames at regular intervals thereafter, to provide a fresh point of comparison from which to calculate the changes. The mathematical principles of Discrete Cosine Transform (DCT) lie at the heart of most of this work.

All data in a digital environment, including sound and pictures, must first be digitized – reduced to numeric code – either when the programme is made, or with special facilities within the delivery system itself, when the programme is presented. If the data are to be compressed, algorithmic calculation can then be applied; digitizing may proceed compression, but it is a critically different activity.

The digitized data in a single image are then usually divided into blocks of pixels, eight by eight square, which can be described in a set of 64 numeric codes, analogous with the chrominance and luminance signals which comprise the visual signal.

Intraframe compression then applies a sort of pass-or-fail test: codes which meet the level set for the system are retained, and the rest are effectively discarded. *Interframe* compression compares codes in a series to detect where changes occur, and what these changes mean.

Full-motion, full-screen, full-colour

In conventional film and video, frames are effectively samples taken at regular intervals from a steady stream of visual information. Thus, the same compression techniques can be applied to video frames as to digital audio samples. For example, the number of samples may be reduced by discreetly dropping a single frame at regular intervals. The missing data can be replaced in the decompressed signal with artificially-generated frames based on adjacent samples.

The speed and volume of visual information can also be reduced. We are used to video which fills the screen with smoothly moving and richly coloured images. However, the size of the image on the screen, the speed at which it moves and the number of colours appearing at any one time can all be adjusted in applications which do not require full-screen, full-motion, full-colour video.

The presentation of 25 or 30 frames a second in conventional full-motion video creates the illusion of movement by providing at least twice as much information as the brain can process in so short a space of time. However, a rate of even 12 or 15 frames per second is sufficient to provide moving pictures, albeit of a lower quality than 'full-motion' video. Just as audio systems may use more frequent samples for high-quality stereo music than speech alone, so video can employ the frame rate appropriate to the quality of images required.

Similarly, the video picture does not need to fill the screen. Current tastes in television production positively favour the use of windows within the screen as a creative technique. Partial-screen video reduces the amount of information needed at any one time, and can be an effective stylistic technique as well.

Most compression systems provide windows, and allow designers to adjust their size and position throughout the programme. Systems which can *only* display 'partial-screen' moving video within windows are defined by the maximum size of that window, expressed as a percentage of the full screen (a 12.5 per cent window, for example, fills one-eighth of the full screen).

The corollary of partial-screen windowing is partial-screen updating, which uses the principles of frame differencing to change the image only in part of the screen. With

this technique, a talking head may fill the screen, but movement is confined to the lips and eyes of the speaker, where the display is updated as invisible windows of changing information within a larger, static image.

The discreet use of colour can also reduce the volume of information needed to present an acceptable picture on the screen. Of the 16.7 million colours available in some computer-based products, a few hundred are sufficient for most graphics, and a few thousand for subtler photographic images. Some systems provide a palette of colours, from which only a given number can be displayed at any one time. Whatever the options, the designer controls the choice of colours and visual quality for every image or sequence in the programme, so the finished product should ultimately reflect creative choices rather than technical limitations.

MPEG, JPEG and ISO

By the spring of 1990, the International Standards Organization (ISO) had received two dozen proposals for video compression algorithms (and over a dozen more for audio codes) from organizations in America, Europe and Japan. The ISO co-ordinates the long process of reaching a consensus in which most or all of the companies, institutions and other interested parties agree to accept and support a common standard. Even when a proposal is widely supported, it usually takes some years to establish an official ISO standard.

Three groups are working specifically to establish standards for still and moving video compression:

- The Joint Photographic Experts Group (JPEG) addresses standards for the storage and dissemination of still images.
- The Motion Picture Experts Group (MPEG) is concerned with compressing video and audio signals within the bandwidth available to data in CD-ROM.
- Px64, of the Consultative Committee on International Telephony and Telegraphy (CCITT), addresses compression techniques for teleconferencing.

These three groups (and their various sub-groups) draft the proposals which will eventually describe standards not only for multimedia platforms such as those discussed here, but also for broadcasting (including network television, satellite and cable systems), and data distribution systems such as Local and Wide Area Networks (LAN and WAN) and Integrated Services Digital Networks (ISDN). These standards will dictate how still and moving images are stored and processed on media including

hard and floppy computer disks, LaserDiscs, compact discs and digital audio tape (DAT). The principal manufacturers in the multimedia market are involved, so many commercial products are being developed with these emerging standards in mind.

- JPEG is concerned with 'spatial redundancy' or intraframe compression – that is, reducing the volume of data required within a single still image – rather than moving pictures or sound. However, some manufacturers have extended these principles to produce 'moving JPEG' as an interim solution.
- MPEG's draft standard addresses spatial and temporal redundancy, and employs a combination of intra- and interframe compression to reduce both the volume of information *within* a single frame of video, and *between* adjacent frames in a moving sequence.

MPEG submitted their first-stage draft proposal in September 1990, as JPEG and Px64 were being implemented as draft standards. However, JPEG and MPEG have been accepted in principle by most of those involved with the new multimedia platforms. Products including chipsets and interface boards have been based on the draft proposals, and MPEG is already the *de facto* standard for full-motion, full-screen video (FMFSV) on CD-I and other platforms.

- The first product to meet the JPEG standard on a single chip was the CL-550 decoder and processor developed by C-Cube Microsystems, with JVC (Japanese Victor Company). It was launched in the spring of 1991, as the first high-performance video decoder and processor which could decompress digital video in real time.
- C-Cube's CL-950 decoder and processor supports the MPEG draft standard in NTSC, PAL and SECAM consumer players. It was first demonstrated in the spring of 1991, supporting compression rates of 200:1. With a resolution of 512x300, it presents better-quality images in slow- and full-motion than VHS videotape.
- At the end of May 1991, Philips announced that they would work with C-Cube to develop full-motion, full-screen video for CD-I; a year later, with the release of CD-I in Europe, C-Cube expected to deliver MPEG video on CD-I by the end of 1992, Motorola announced two chips for video processing on CD-I, and GTE demonstrated prototypes of interactive television services from CD-I.

In the first generation of products at least, a minimum of two interface cards are required by the computer to digitize analogue video signals, and then compress and decompress

these digital data. In practice, only the programme-maker may need the compression card, for a decompression card alone can deliver a recorded programme to its users. Fully digital systems, or another generation of products, should obviate the need for the video capture card, and many developers hope that the whole package can be reduced to a single chipset by the late nineties. Developers are pursuing these ends in radically different ways. For example:

- Complement Corporation produced a low-cost software package which, in the spring of 1990, could compress video and audio signals in real-time at a rate of 12:1 without additional hardware. The compressed data could be transmitted through a network or over telephone lines.
- Compression Labs developed a system in 1990 which was reported to reduce video data by a factor of 6000 for use in teleconferencing and video phones.
- Iterated Systems first applied the principles of fractal geometry to support compression at rates from 20:1 to 64:1, using two interface cards, in 1990. Its developers believe that, with sufficient processing power, the technology could ultimately reduce audio-visual data by a factor of 10 000. Their Software Video Player, demonstrated in the spring of 1991, employs fractal geometry to support full-motion video in a PC with industry-standard VGA graphics (described below), and no additional hardware, at rates of 76:1 for high resolution, or 160:1 for high compression.
- JVC themselves in 1990 demonstrated the prototype of a compression system which could deliver a full-length film on two compact discs, and entered the standards debate with a compression algorithm of their own called 'JVC Extended', which could be up to four times faster than MPEG. Their first chipset, released in 1991, supports JPEG and MPEG as well as JVC Extended.
- Storm Technology demonstrated the first software application of the JPEG standard for an Apple Macintosh with Picture Press, which was launched at CeBIT 1991 in Hanover, Germany, in March 1991.

The term VGA refers to the computer graphics benchmark established by IBM's Visual Graphics Adapter (VGA) card, introduced with their Personal System/2 (PS/2) computer range. VGA offers a high resolution image (in computing terms, 640x480 pixels) without interlacing, and presents up to 256 colours on the screen at any one time, from a palette of 262 144.

Compression and decompression are clearly volatile markets in the early nineties, and standards are still a fast-moving target. However, products such as CD-I and

CDTV are designed so that, as MPEG and other standards are codified, they can be upgraded to meet prevailing standards.

PHOTO COMPACT DISC (PHOTO CD)

The jury was still out on the case for compression in September 1990, when Kodak announced Photo CD, which is to photographs what CD-DA is to music. In Photo CD, as in CD-DA, the large and versatile storage capacity of a compact disc is dedicated to the reproduction of a single medium, in relatively small quantities but at a higher level of quality than the consumer market has yet known.

Photo CD storage capacity

The compact disc that will hold nearly 20 hours of 'telephone quality' sound carries little over an hour of digital audio in CD-DA. Similarly, although a CD-ROM might hold several thousand still images for archival purposes, a Photo CD stores no more than 100 – but at a resolution of over 18 million pixels per image. That is 16 times greater than NTSC television, and four times that which high-definition television (HDTV) can yet display. For storage on compact disc, each image is compressed to about 6MB (hence, 100 images per 650MB disc).

Photo CD meets the functional specifications of the *Orange Book* for recordable compact discs, and the CD-ROM XA 'bridge' between CD-ROM and CD-I. Before the product was launched, Kodak announced the proposed addition of video, as well as facilities to allow consumers to record audio on domestic Photo CD systems (and, thus, create multimedia presentations at home).

In its first generation at least, Photo CD is designed for 35mm film alone, not the least because the lower image quality from snapshot cameras hardly supports reproduction at high resolution. If anything, the logical extension of Photo CD would be in the other direction, into higher-quality professional formats. Nonetheless, Kodak reckon that at least 250 million cameras now produce some 60 billion images a year on 35mm alone.

In 1990, Kodak conducted detailed market research with 1000 consumers in the US, the UK and Germany, and found that they not only grasped the principle of the system without difficulty, but fully half found it 'very appealing' – a promising result in preliminary research for new technology.[4]

In the Photo CD system, 35mm film is processed normally, and its images are then transferred to disc through Kodak's Photo CD Authoring System (PAS). Within the Photo CD processing unit, the image is scanned and digitized (that is, converted to a computer graphic as digital data). It passes to a dedicated desktop computer called an Image Data Manager (IDM), similar to those already used in high-speed photo-finishing units, to correct the exposure and colour balance where necessary. This unit also produces a record of 'imagettes', or thumbnails, which show a tiny reproduction of every shot for the visual record on the cover of the CD 'jewel box'.

Customers simply bring in their films for processing, and for a premium of about £10/$20 will receive, in addition to a conventional set of prints, a Photo CD disc in the familiar plastic jewel box. The imagettes, displayed together like a page of decorative postage stamps, provide the cover. The discs can be built up over time, so one Photo CD disc might hold four rolls of 24 exposures each, shot over the course of a year and processed in four separate operations.

Photo CD delivery systems

Photo CD will be easy and cheap enough to appeal to the many outlets which now provide photo services to their own customers and to shops and agencies. (The launch price, of about $100 000, compares to the present cost of the processing and printing systems employed in local photo shops.) The whole unit fits easily into a small desk space, with a Kodak film scanner, Sun Microsystems workstation, Philips compact disc writer, and Kodak thermal printer. Kodak will supply both blank recordable discs and thermal paper.

The Photo CD disc itself can be played in a dedicated Photo CD player, for display on a standard NTSC, PAL or SECAM television, or a computer screen. Like CD-I, Photo CD discs can be played anywhere in the world, whatever the local television standard: the player itself converts the digital data on the disc into the appropriate signal for the monitor.

Because of the technical differences between NTSC and PAL/SECAM, the full horizontal or 'landscape' image will be displayed on a PAL or SECAM monitor, but will be slightly cropped in NTSC systems. Similarly, users will have to 'scroll' up and down the screen to see the whole image in vertical or 'portrait' formats.

Photo CD was designed to be compatible with CD-ROM XA and CD-I (albeit at lower resolution, initially at least), so a Photo CD disc can be played on either of those delivery systems, and will adapt to CDTV and HDTV standards, too.

Photo CD applications

Photo CD disc replaces negatives as a source for prints, enlargements and other reproductions. It also allows users to create their own slide shows on the TV or computer screen, and even to zoom in and 'crop' the display on the screen without affecting the permanent image on the disc. Whole discs can also be replicated.

The limit of 100 shots per disc is about as many as consumers can easily handle without more complex indexing and retrieval systems. However, Photo CD also includes many features for professional applications such as desktop publishing and presentation aids. Home computers could compile electronic photo albums, and even small businesses could economically distribute brochures and catalogues on a CD which customers could play at work or at home.

The quality of the Photo CD image is also better than that of conventional transparencies as a source for reproduction on paper or transfer to other display systems. With image processing software, pictures from the Photo CD disc can be captured and manipulated in desktop applications for publishing and computer-based displays of all kinds, from the family Christmas card to a daily newspaper.

The disc can also be linked to a database which, typically, would note important details observed in the photos, and use these keywords for searches which would then retrieve all the images of potential interest. With the addition of audio, this might include commentary or sound effects. (Even before the product was launched, Kodak saw the potential here when the US Department of Fish and Wildlife asked how they might search and compare information in a collection of pictures of manatees, an endangered sea mammal found in Florida: Photo CD and a database software package would support a versatile archive in words, statistics and high-resolution images.)

Photo CD has many of the characteristics of recordable videotape, as a product which consumers can use for their own ends, in ways which may surprise the industry which developed and launched it. Its compatibility with CD-I adds value to both products, and helps to build the case for multimedia on a compact disc in the consumer market. And, like CD-I before it, Photo CD made *Popular Science* magazine's Top 100, 'The Best of What's New', in 1990.

DIGITAL VIDEO INTERACTIVE (DVI) TECHNOLOGY

Digital Video Interactive (DVI®) is, properly, not a noun but an adjective, not a product but a process. DVI technology embodies a set of compression algorithms in a chipset,

which is in turn mounted on a circuit board for installation in a computer. (The 'food chain' emerged as a popular analogy in the multimedia industry at about the same time as DVI chipsets and C-Cube boards began to influence the design of delivery systems.)

DVI technology was conceived at RCA's David Sarnoff Research Centre in Princeton, New Jersey, and developed initially by RCA and General Electric. In October 1988, Intel bought out RCA and GE, and hired the development team from SRI International to join Intel's Microcomputer Components Group. In March 1989, IBM threw their weight into the development of DVI technology as an emerging standard for desktop video. The system also enjoys the support of Matsushita in the Far East and Olivetti in the European market, amongst others.

One significant feature of the DVI concept is that it is largely 'platform-independent': the product is a programmable chipset, which can be installed in a variety of systems, and not a delivery platform *per se*. The chipset, being programmable from software, accommodates upgrades of the technology without requiring hardware – an advantage in a rapidly-changing market.

DVI graphics and video

DVI technology was launched before the work of JPEG or MPEG began to set *de facto* standards, and has of necessity developed its own algorithms for a choice of compression levels and visual quality:

- Picture Image Compression (PIC) supports the 'symmetric' compression and decompression of still images in real time within the PC, at ratios of 150:1.
- Real Time Video (RTV) supports the symmetric compression and decompression of full-motion, full-screen video in real time within the PC, but at a lower level of quality than VHS videotape.
- Production Level Video (PLV) is an asymmetric system, which supports the decompression of full-motion, full-screen video in real time within the PC, at a level of quality equivalent to VHS videotape, but requires special facilities to compress these data (a service, at time of writing, provided only with a mainframe computer at Intel's American headquarters).

The 'B' series of the i750 chipset, released in November 1990, supports NTSC, PAL and SECAM as well as IBM's XGA computer graphics and JPEG's draft standard (both new at the time). Intel were instrumental in the drafting of MPEG's recommendations, and promise that DVI will incorporate new industry standards as they emerge.

As DVI technology is platform-independent, images processed in this way can be stored on virtually any high-volume medium. CD currently affords the optimum combination of features, so DVI-based applications tend to be CD-based as well. On a single compact disc, DVI technology typically offers a choice of:

- Up to 72 minutes of motion video at low resolution;
- Up to 7000 high-resolution images at 768x480 pixels;
- Up to 10 000 medium-resolution images at 512x480 pixels;
- Up to 40 000 low-resolution images at 256x240 pixels.

DVI delivery systems

DVI products are not designed within the constraints of any one hardware specification, and can therefore be applied to a variety of delivery platforms. However, the technology was conceived within the *de facto* standard set by the IBM PC, so the delivery platform was initially based on a 'fast' PS/2 with a 286 or 386 processor and MS-DOS operating system. Versions have been developed subsequently to run under OS/2, UNIX and Windows, and the Apple Macintosh.

The DVI environment currently requires two interface cards for authoring (one for compression, one for decompression):

- The ActionMedia Capture Board captures, digitizes and compresses PIC and RTV audio-visual data on the host computer's own hard disk.
- The ActionMedia Delivery Board decompresses and processes data in DVI formats from the hard disk, a CD-ROM or other optical storage medium, or an external source such as a computer network.

Only the decompression card is required in the delivery systems, which can thus be less complex and expensive than the authoring station, and still offer a range of facilities to process and manipulate audio-visual, textual and numerical data. The plan supported by the power of Intel and IBM is that DVI facilities will be reduced from a set of plug-in boards to a component of the computer's own motherboard by the mid-nineties, and to a microprocessor by the end of the decade. If this is achieved, DVI technology could become a standard feature of all desktop computers, as common by the year 2000 as the hard disk was by 1990.

In the meantime, several manufacturers and developers now provide tools and products to facilitate the creation and delivery of training and information packages using DVI technology, some of which are described in Chapter 3.

DESKTOP VIDEO (DTV)

If all goes well, 'desktop video' will be a flash in the pan, and multimedia products for computers will soon be as common as spreadsheets. For the term really describes any system which combines still and moving pictures, text and sound within a desktop computer. As graphics packages grow more elegant, and the use of capture devices makes it easier to incorporate complex images into computer-based displays, desktop video should become a standard feature in all computers.

Desktop video is distinct from interactive video in that all data are held on computer media such as hard disks, and not supplied from a dedicated audio-visual medium. The AV material may be created with hardware and software in a developer's studio, but is typically processed through software alone within the end-users' delivery system.

Desktop video standards

Desktop video can be delivered on any of a number of computer-based systems. However, without central co-ordination, a proliferation of standards and products could fragment this market like the CD-ROM and IV markets before it.

Bill Gates of Microsoft, the company behind Windows and other successful software products, argues that standards are the key to achieving critical mass in the multimedia market. Speaking at Microsoft's Fifth Annual CD-ROM Conference and Exposition in San Francisco in the spring of 1989, he identified four criteria for a successful international market as: a standard integrated hardware platform, standard system software, standard data formats and tools, and good applications.

Under his aegis, Microsoft led an initiative to establish standards for desktop video. The Multimedia PC (MPC) group is specifically concerned with multimedia products and services for the IBM PC environment. As well as recommending standards, MPC issue a trademark to identify products compatible with its specification. These include complete delivery systems, and upgrade kits for equipment already in the field. MPC had attracted 60 licensees by the time the first hardware was released, in October 1991, alongside some 60 software titles.

MPC's initial specification for multimedia on the PC requires a 286 (10mHz or faster), 386 or 486 CPU processor with 2MB RAM and a 30MB hard disk, VGA video display, digital audio subsystem and CD-ROM drive. Systems software must be compatible with the applications programming interfaces (API) of Microsoft Windows 3.0 with multimedia extensions, or equivalent APIs.

Desktop video on industry-standard computers

Several manufacturers now produce hardware and software products for desktop video. IBM's Audio Visual Connection (AVC) and M/Motion Video Adapter offer a variety of facilities to incorporate still and moving video and graphics, audio and hypertext into presentations which can be stored and run entirely on a desktop computer. In the autumn of 1991, IBM released the PS/2 Ultimedia computer with features including a CD-ROM drive and audio capture facilities. Its position was soon refined to include a 'base case' specification which could encourage developers to treat Ultimedia as an independent multimedia platform.

IBM and Apple are now collaborating on new products, but there is still a technical gulf between PC and Macintosh environments. Popular applications software has been adapted for use on either platform, as have technologies such as DVI, but many multimedia development tools are as yet accessible only to one or the other.

Apple believe that digital video is integral to the future of desktop computing, and are extending their product range to encourage both developers and end-users to think so, too. QuickTime provides a multimedia toolkit which can add desktop video facilities to any Macintosh applications software, using virtually any compression algorithm. QuickTime's features include a 'Movie' Toolbox (which handles sound, video and animation), an Image Compression Manager (for a variety of compression schemes including DVI and MPEG), three proprietary compressors (for still video, animation and moving video), and a Component Manager (which integrates peripheral hardware boards, devices and system software extensions). The key words are 'flexibility' and 'extensibility', to allow developers to choose freely from the many hardware and software products on the larger market, and create the working environments and finished products appropriate to their individual needs.

Many multimedia developers now use a combination of PCs, Macs and Amigas in the same studio, applying the strengths of each to appropriate production activities. However, such decisions must be informed by careful research, not only through the product literature, but also through the magazines and newsletters which alone are frequent enough to keep abreast of this rapidly changing market.

COMMODORE DYNAMIC TOTAL VISION (CDTV)

CDTV is the very much the product of one manufacturer. Commodore are strong in the home computer market, particularly in games. They released their first multimedia

computer, the Amiga 3000, in April 1990, and CDTV a year later. CDTV, too, is associated particularly with one personality, Nolan Bushnell, who invented the first video game (Pong), founded Atari, and in 1990 became General Manager of Commodore's Consumer Interactive Products Division.

CDTV was the first multimedia CD product to reach the consumer market. Two fundamental decisions helped Commodore slip ahead of the competition:

- CDTV is based on standard components, which simplifies both the design and manufacture of hardware, software and accessories.
- CDTV was launched without full-screen, full-motion video, with a player designed to be upgraded when a standard chipset makes this practicable.

The player was launched in April 1991 for recommended retail price of $999 (US) or £600 (UK). In Britain, the player's three 'bundled' programmes provide buyers with a 'welcome disc', *Hutchinson's Electronic Encyclopedia*, and a game. The CDTV delivery system includes a number of other sockets, ports and drives for optional accessories which can customize the standard consumer player into a low-cost Level 3 delivery system for professional or domestic environments.

CDTV storage and facilities

A CDTV player can accept multimedia packages on CD-ROM (ISO 9660), CD-DA or CD+G. A CDTV disc can hold up to 540MB of digitally-encoded data, with a flexible combination of sound and pictures, text and data.

CDTV offers resolution at 640x512 (PAL) with up to 4096 colours. The player is compatible with CD-DA, and supports two stereo channels. On its release, the system supported only still video and animation. However, Commodore even then could demonstrate partial-screen video, at rates of 12 to 15 frames per second, with their own CDXL extension, and announced that CDTV will support MPEG's draft standard as soon as its recommendations become commercially viable.

CDTV delivery systems

CDTV is essentially a fusion of an Amiga computer with a CD-ROM drive. It employs Commodore's own Amiga Kickstart operating system (and is, therefore, incompatible with DOS-based CD-ROM discs or CD-I's own CD-RTOS operating system.) The basic CDTV package launched in April 1991 comprises:

- A CD drive (built to ISO 9660) which can handle CD-ROM, CD-DA and CD+G with an average access time of 0.5 seconds (and a maximum of 0.8);
- A Motorola 68000, 16/32 bit, 7.14mHz processor with three customized co-processor chips (cheerfully named Agnus, Paula and Denise);
- An infrared remote control unit.

The player also includes connection points including:

- An Amiga-compatible floppy disk drive;
- A socket for hardwired keyboard, mouse or other input device;
- A socket for stereo headphones, plus two Musical Instrument Digital Interface (MIDI) audio ports, in and out, for devices such as electronic keyboards;
- An RS232 serial port and Centronics parallel port for other hardware;
- A port for an optional credit card sized 'personal memory card'.

Within the player, there are expansion slots for:

- An 'intelligent video' card (e.g. genlock), plus a 25-pin edge connector;
- A Direct Memory Access (DMA) slot for a Standard Computer System Interface (SCSI), or Local Area Network (LAN), to facilitate the use of CDTV in professional applications and workstations.

Other accessories include a trackerball and mouse; a 'game controller' with joystick, battery saver and optional mains' connection; and 'book shelf speakers' to enhance audio when the system is not connected to the hi-fi.

Another class of accessories could transform CDTV from a home entertainment system to a creative tool and low-cost delivery system for education or training. Video genlock cards in PAL and NTSC allow CDTV images to be mixed with a separate video source such as a camera, disc, tape or television signal, in the manner of interactive video. Personal memory cards, similar to those used in some hole-in-the-wall bank services, offer 64KB or 256KB storage capacity to record scores or moves in a game, student records, security codes or even short control programs to customize CDTV packages for individual use.

CDTV authoring

A number of authoring packages emerged alongside the CDTV player itself, to encourage designers without formal computer programming skills to develop software for the system. The first generation include Commodore's own Amiga-Vision

(developed for use with Amiga A2000 and A3000 computers), Digigraphic's Living Book Publisher, and Inovatronics' CanDo.

CD-ROM EXTENDED ARCHITECTURE (CD-ROM XA)

CD-ROM XA is often described as the 'bridge' between CD-ROM, with its limited processing facilities, and CD-I, a true multimedia platform. CD-ROM's 'extended architecture' addresses the separate demands of text, audio and visual data by introducing compression techniques and recording data more efficiently, to improve storage capacity and processing power. XA is an extension of the *Yellow Book*, which outlines functional specifications for CD-ROM, rather than a platform in its own right.

XA addresses the shortcomings of CD-ROM by interleaving data of various kinds – that is, *not* by sending all the text, all the audio and all video, in three separate dispatches, one after the other (as CD-ROM would), but by sending small portions of each type in a smooth stream which the system can process steadily. XA also encodes data so that audio-visual information can go directly to the appropriate processor, without first passing through the central processing unit. Interactive multimedia systems by definition demand a constant flow of new information as the programme unfolds: CD-ROM XA, through these various innovations, supports this requirement more efficiently than CD-ROM alone.

CD-ROM XA graphics and video

CD-ROM XA can support not only text and graphics, but still and moving video. XA offers two of CD-I's four graphics formats, to provide:

- Up to 6340 graphics (e.g. computer-generated images) with up to 256 colours on any one screen, from an ultimate choice of 16.7 million;
- Animation (e.g. line drawings with limited areas of motion) with up to 128 colours, the complexity of which determines the storage space required.

Full-motion, full-screen video is a demanding medium, as the notes above and in the appendices explain. XA was designed to support a modified version which runs more slowly than usual (typically, at 12 to 15 frames a second, to PAL's 25 and NTSC's 30). Such images are not as smooth as true video, but they are not distracting – particularly when they are displayed within windows on the screen, and framed by graphics or text.

CD-ROM XA audio

Like CD-I, CD-ROM XA can employ up to 16 separate (mono) audio channels. These can be paired to produce high-quality stereo sound, or deployed individually to provide large quantities of audio to accompany text and pictures.

Like CD-I, CD-ROM XA employs Adaptive Differential Pulse Code Modulation (ADPCM), a variation of the PCM encoding techniques of CD-DA discs. This offers various levels of fidelity, with a trade-off between storage and processing capacity, and audio quality. CD-I offers ADPCM audio at three levels of quality; CD-ROM XA supports only two of these, Levels B and C, equivalent respectively to FM and AM broadcast radio. Thus, the XA format will support:

- Up to 4.8 hours of stereo at FM broadcast quality, or 9.6 hours of mono;
- Up to 9.6 hours of stereo at AM broadcast quality, or 19.2 hours of mono.

ADPCM also supports interleaving, by allowing room for other data alongside the audio signals. This, of course, varies according to the quality of the audio – Level B stereo requires more data, leaves less spare capacity, than Level C mono.

CD-ROM XA delivery systems

CD-ROM XA conforms to the volume and file structure of ISO 9660. As 'extended architecture' is essentially an enhancement of established principles, most current CD-ROM drives can be upgraded to handle XA with the addition of an interface card (such as those supplied by both Sony and Philips). Thus, the delivery system is superficially no different from that required for a computer with a CD-ROM drive – providing that appropriate output devices are available to handle high-resolution images on the monitor, and sound through headphones or an amplifier and speakers.

One long span in XA's bridge between CD-ROM and CD-I is its support of two computer operating systems: DOS (Disk Operating System) which is a *de facto* standard employed by many CD-ROM systems, and the CD-RTOS (CD Real-Time Operating System) unique to CD-I. This means that delivery systems equipped for CD-ROM XA could also handle CD-ROM databases for a conventional PC environment, and CD-DA discs. At the same time, some programmes developed for CD-ROM XA can be played on CD-I systems. Technical compatibility at this level means that multimedia publishers can develop one product for two or more markets. (The practical aspects of cross-platform development are discussed in Chapter 9, Stages in Production.)

COMPACT DISC-INTERACTIVE (CD-I)

As the subject of this book, CD-I is of course described in greater detail in the chapters which follow. This section provides an overview for comparison to other platforms described in this chapter.

CD-I, like CD-DA, was initiated by Philips of Eindhoven, but developed in cooperation with other manufacturers, including Sony and Matsushita. Philips and Sony announced preliminary specifications for CD-I in March 1986 and issued the first provisional specification that June (just as the High Sierra group were completing their draft standard for CD-ROM). The first full functional specification, the *Green Book*, was released a year later, and published in November 1988 for release to fully-licensed CD-I developers. After some slippage (chronicled in Appendix 4), the first consumer players were released in the US in October 1991, and in Europe, Japan, Mexico and other markets from April 1992.

Like other compact disc formats, CD-I was developed without full-motion, full-screen video (FMV). Philips showed a videotaped demonstration of FMV from a CD-I disc in Washington DC in May 1989, and from a CD-I player itself in Tokyo in October. CD-I was the Grand Winner in the Video Category of *Popular Science* magazine's Top 100 new ideas, 'The Best of What's New', the next month.

In April 1987, Philips and PolyGram formed American Interactive Media (AIM) – later Philips Interactive Media of America (PIMA) – to co-ordinate the development of CD-I software in the US. A number of other joint ventures – including OptImage and Capitol Disc Interactive – were established to develop software, authoring tools and other products. CD-I developers' consortia formed in Japan, the US and Europe to co-ordinate the work of programme-makers and publishers.

CD-I was designed primarily as a consumer product, although industrial-quality players are available, and many professional applications in marketing and training were undertaken well before the product was launched. The consumer player comes in one tidy box, which is easily connected to the TV and hi-fi.

The hand-held control unit, with its miniature joystick ('thumbstick'), will be the most unusual feature for most consumers, although many home computer users will be familiar with its conventions. (A mouse and rollerball are optional accessories.) Many CD-I products for the consumer market are designed so that novices can start simply by watching, and the many features and benefits of interactivity can be explored as users' interest and confidence grow. The adventurous will be rewarded with new and unprecedented forms of entertainment and information.

CD-I graphics and video

CD-I offers four encoding methods for still and moving pictures, some of which can in turn be delivered at various levels of quality for images of different kinds:

- Up to 6340 photographic images (e.g. slides, colour transparencies or still video frames), combining up to 16.7 million colours;
- Up to 6340 simple graphics (e.g. computer-generated images) with up to 256 colours on any one screen, from the ultimate choice of 16.7 million;
- Up to 3170 complex graphics with up to 32 768 colours at one time;
- Animation with up to 128 colours at a time, the complexity of which determines the storage space required.

These formats support a number of special effects, which are discussed in more detail in Chapter 7, Audio and Video on CD-I. The technical aspects of video on CD-I are explained in that chapter, and discussed again in the chapters on Stages in Production, Screen Design and Programming.

Although full-motion full-screen video has been demonstrated, CD-I was launched without this feature, on players which can easily be upgraded. In the interim, CD-I supports full- and partial-motion video windows, and techniques such as partial-screen updates and animation provide movement and variety in images of various kinds.

CD-I sound

CD-I offers four levels of audio, with the inevitable trade-off between quality and quantity. One CD-I disc, dedicated exclusively to audio, could provide:

- Up to 72 minutes of digital sound on two stereo channels equivalent in quality to a CD-DA disc;
- Up to 144 minutes (2.4 hours) of high fidelity sound on two stereo channels equivalent in quality to a new vinyl record (Level A);
- Up to 288 minutes (4.8 hours) of mid-fidelity sound on four stereo channels equivalent in quality to FM radio (Level B);
- Up to 576 minutes (9.6 hours) of low-fidelity sound on eight stereo channels equivalent in quality to AM radio (Level C).

In practice, CD-DA quality is rarely necessary in a multimedia application. Level A provides excellent stereo sound where quality is important (for example, in an excerpt of classical music), while Level B is appropriate for background music and theme

tunes, and Level C carries the spoken word and sound effects economically. Of course, with audio as with video, various encoding methods can be used to supply sound and pictures of a quality appropriate to each part of the programme. Clearly, this is the beginning of the many technical and creative trade-offs which multimedia productions in all formats demand from their designers, to find the optimum balance between quality and economy. The technical aspects of audio on CD-I are discussed more fully in Chapter 7, Audio and Video on CD-I, and in Chapter 9, Stages in Production, and Chapter 11, Programming.

CD-I delivery systems

CD-I was conceived primarily as a consumer product, so the player is not dissimilar to other CD or home entertainment systems. A single box, with one cable to the TV, and one to the mains (and, optionally, to the hi-fi or speakers), fits comfortably into the living room, bedroom or study. CD-I is compatible with standard NTSC, PAL and SECAM televisions and monitors, and domestic hi-fi systems.

CD-I's technical specification, the *Green Book*, defines a 'base case' to which all CD-I players must conform. This specifies facilities for both programme-makers and consumers, and ensures that all CD-I systems provide the same essential features. At the heart of every player lies the CD-Real Time Operating System (CD-RTOS). This unique modification of a well-known computer operating system was specially designed to support the presentation of multimedia displays in real time – that is, immediately on demand – in a consumer product.

CD-I discs share many features with other compact disc formats, just as CD-I players share many features with other computer-based display systems. A fuller technical description of both is provided in Chapter 6, CD-I Discs and Drives.

By the summer of 1991, over 40 companies were licensed to manufacture CD-I players, to a common standard but with a variety of features. Philips were the first on the market, but manufacturers include Fujitsu, Panasonic, Pioneer, Ricoh, Sanyo-Fisher, Sharp, Sony, Tandy and Yamaha. One novelty in Philips' first professional model, after a decade of black and grey, is its colour scheme: off-white with pastel green and pink details. The first consumer models, however, favour the dark metallic finish of other consumer AV products, so that the CD-I player will blend in with the hi-fi and VCR.

CD-I is being used in corporate markets for training, education, marketing and public information. Philips introduced their first two single-box CD-I players,

Models CDI 601 and 602, to the professional market in October 1990. Both support digital video and audio processing for display on PAL and NTSC televisions or RGB, Y/C or CVBS monitors. Both have two standard CD-I in/out ports and two RS232 serial ports. The CDI 602 includes a 9cm/3.5 inch floppy disk drive. (The development of portable CD-I players is discussed below.)

CD-I standards

Unlike CD-ROM, CD-I was conceived and developed as a self-contained system with all its ground rules clearly defined from the outset. The structure of the disc is consistent no matter what the disc contains, or who produced it. Thus, any CD-I disc can be used on any CD-I player, no matter where the disc or the player were made or purchased. CD-I supports a universal standard, so a CD-I disc is as portable as a vinyl record or audio cassette.

The problems of technical standardization for full-screen, full-motion video of course affect CD-I as well as all the other compact disc formats. The product was conceived before JPEG and MPEG, and supplied to developers while JPEG were still drafting their recommendations. With CD-I as with CDTV, the system is designed to be upgraded when products exist to support an agreed international standard (even if that is, necessarily, a draft proposal on its way to full adoption).

Thus, the CD-I specification is not so rigid that it cannot be refined, but neither does it encourage independent developers to introduce non-standard features which will fragment the market for hardware and software. That has been, for various reasons, the effect of unco-ordinated development in the interactive video and CD-ROM markets, and CD-I for one has benefited from those examples.

ELECTRONIC BOOKS

The first demonstration of Sony's Data Discman was reported by *The Videodisc Monitor* in March 1990 in the 'Wow, Neat Stuff Department', but miniaturization in the multimedia industry has hardly yet begun. CD drives stack neatly within the home entertainment centre or desktop computer, but there is a much larger market waiting for portable players as light and convenient as radios or audio cassettes.

- Sony's Data Discman holds some 100 000 pages of text or 32 000 images on a 8cm/3 inch CD-ROM disc, in a 15cm/6 inch square box which provides both the

CD-ROM drive and a 10-line screen in one 675gm/24 oz. package. It can be connected to a TV for a larger display, and to a keyboard for retrieval facilities such as keyword searches. With an earphone, the Discman also plays mini-CD audio discs. Sony launched the product in Japan in July 1990, and sold 340 000 players and 200 000 discs there by the time the Data Discman was launched in the US, in November 1991. The player is bundled with three software titles (typically, encyclopedias and dictionaries); in the US, the suggested retail price on launch was $550.

- Cornucopia, first demonstrated by Empruve in August 1990, uses DVI technology to display colour video and graphics. It combines a 25cm/10 inch black-and-white screen with 640x480 VGA resolution for text and graphics; a 10cm/4 inch colour screen with 480x240 resolution for still or moving DVI images; a control panel with room for 15 icons; two stereo speakers and a headphone jack; and a joystick with four programmable tactile switches. The system uses a point-and-click navigation system, and can display text and graphics in vertical (portrait) or horizontal (landscape) formats. It can employ a combination of built-in hard disk and removable high-density magnetic and optical discs. Thus, a CD-ROM could hold 40 000 pictures, four hours of video, or some 2000 books on a single disc.
- In the autumn of 1991, Philips and Sony announced plans to develop electronic books for a dedicated CD-ROM XA player, to be compatible with CD-I.

Many commentators believe that the real success of CD-I will lie in portable players, when these are small, powerful and inexpensive enough to serve as hand-held games machines, and professional information tools. Sony were first to demonstrate a portable CD-I system – with 10cm/4 inch colour screen, CD-I disc drive, three control buttons, and a socket for head or earphones – in June 1990. The enthusiasm of other manufacturers (including Kyocera, Matsushita and Sanyo, who have all developed hand-held players) strongly suggests that a portable multimedia machine, rather than another accessory for the home entertainment centre, could be the real key to success for interactive CD.

RECORDABLE AND ERASABLE DISCS

Most of the LaserDisc and CD systems described here employ media which, like vinyl records, present their users with immutable recordings, which cannot be erased or re-recorded. The disc can be damaged (although less easily than a record or tape), but its

contents are otherwise inviolable. Information on the disc cannot be corrected or removed without reworking the master, and pressing fresh copies of the disc.

If the computer program which controls interactive use of the disc is recorded separately (for example, on a hard or floppy disk), it can be rewritten to skip the offending segment or remove reference to it from the program. Alternatively, if text or graphics are supplied from another source (again, typically, computer disk), correct information may be supplied as a separate computer-generated segment, or as an overlay superimposed on the screen. These options, obviously, favour interactive video systems which store different parts of the interactive programme on different media, or desktop video packages with erasable hard disks.

Recordable optical discs certainly exist. For pure data storage, WORM (Write Once, Read Many) technology allows many organizations to store archival material securely and compactly on discs which, like audio or video tapes (or Photo CD), can be recorded sequentially as data become available. WORM systems typically have such large data storage capacities that it is often only feasible to fill them in stages, at a few hundred or thousand pages at a time. Photo CD is a WORM format, distinguished as such by its reflective golden surface, which uses a different film to the reflective aluminium of pre-mastered formats such as CD-I. There are several systems for the CD-ROM market which allow users to record their own discs in-house, or with a convenient local service. The first internal write-once drive (for use in desktop computers) was announced by JVC in the spring of 1991, as the WO CD-ROM format.

The fact that these discs, once recorded, cannot be erased or overwritten is a singular *benefit* for archivists, for no one can tamper with their contents. WORM systems are ideal for financial and legal data, and the reams of documents which organizations are obliged to retain for prescribed periods. A statutory seven years' worth of tax returns or insurance claims – let alone records which must be kept permanently – require vastly less storage space, and are far more easily retrieved, on disc than on paper.

Optical Memory Disc Recorders (OMDR) produce write-once discs which can be recorded sequentially to compile an image base. LaserDisc technology has established current standards for OMDR systems, but prototypes based on other standards have been demonstrated. Sony, for example, in Tokyo in 1990, showed a magneto-optical (MO) system which holds 24 minutes of video per side, and a portable CD-MO format, as well as two discs for high-definition television (HDTV), one of which is recordable.

For applications such as art or museum collections, recordable videodiscs offer excellent reproduction in full-colour, on a medium which can be linked to a computer database for use unparalleled in printed catalogues or slide collections.

Disc-to-disc transfer is another specialist option. Panasonic and Distronics completed the first known transfer from OMDR to LaserDisc in the spring of 1990. Video from a camera and graphics from a computer were recorded directly on the OMDR disc. The programme (a training package for Dow Chemicals) was tested and then transferred to LaserDisc for replication and distribution. This method obviates the need for a master tape or pre-mastering services, to speed up production and improve visual quality (by reducing the number of 'generations' between the source and the LaserDisc); it also requires considerable competence in the design and production team.

Erasable discs – which can be recorded, erased and re-recorded, like audio or video tapes – are now emerging for the data storage market. Equivalent products for computers, in the form of large-volume hard disks such as the Winchester, dramatically increased the power of the personal computer in the mid-eighties, and are now an essential tool of data-hungry desktop video systems.

The material demands of audio-visual programmes are much greater than those of computer data alone, but it is surely only a matter of time before erasable multimedia systems become technically and commercially viable. The question is whether this will matter to the many people who will use multimedia products to disseminate recorded material which users should not alter. Commercial publishers, and the many organizations which use audio-visual media for training or marketing, may prefer media which cannot be erased or copied.

The attraction of erasable systems may lie in applications which allow users to combine their own recordings with a published programme. This is now being done, rather clumsily, with IV systems which incorporate microphones for audio input, or videotape recorders and cameras, in role-playing exercises which trainees can replay and analyse to evaluate their own performance.

The music and video trades are rightly ambivalent about consumers' use of erasable tapes, and desktop video systems have no answer to the volatile question of copyright. The advantages of erasable media in this market are debatable, and interactive multimedia programmes which cannot be copied or damaged by their users still have considerable appeal to publishers of all kinds.

MULTIMEDIA STANDARDS

Compatibility has been an important word in the IV industry for many years, yet there is still no solution to the multiplicity of products and specifications in that market. The

issues are both technical and commercial, for standards affect hardware manufacturers and software developers, new and established users, and a network of distributors, dealers, consultants and other intermediaries. As a platform, CD-I has the signal advantage of an integrated international standard for all its hardware and software products; however, there are still many incompatible standards in the computing, broadcasting, corporate video and multimedia markets as a whole, which limit what any one product can ultimately achieve.

In the US, the Interactive Multimedia Association established an open forum to address the needs of the many participants in this growing market. The IMA was established in 1988, and within three years attracted over 170 corporate members. The support of large and small organizations is vital, for some *de facto* standards have emerged from the work of relative small companies (VideoLogic and C-Cube, for example). The combination of technical competence, sound business sense and good marketing strategy can take a small company into big markets – particularly when end-users are more interested in buying products which work now, than in supporting long-term initiatives which promise upward compatibility with vapourware.

There are also any number of groups meeting to establish standards within vertical markets. For example, the Society for Worldwide Interbank Financial Telecommunications (SWIFT) – with experience in drafting proposals for standardization and developing IV packages for international markets – launched an initiative to draft *Standards for Technology-Based Training in Financial Institutions* in May 1990. Developers with an interest in vertical markets should look to user groups, professional associations, and initiatives such as SWIFT's, to keep abreast of vital developments in their target sectors.

WINNERS AND LOSERS

Interactive video was viable in the early eighties, but the first applications of any consequence began in the middle of the decade, with a flurry of pilot projects and one-offs, and a few large (and premature) initiatives from companies like General Motors in the US, and Lloyds Bank in the UK. The market has grown more slowly than first predicted (what new market does not?), but some organizations now have successful networks for training or marketing. As one of these is the US Army, with 14 000 units of its Electronic Information Delivery System (EIDS), it may be a bit harsh to condemn IV as a non-runner.

Interactive video is criticized for not having gone farther, faster. It has settled into a niche market, and done little to challenge the ascendency of video or even computer-based training. Or has it? IV has not displaced any other form of communication, but that was hardly its purpose: books, video, computer-based training, even classroom instruction all have clear benefits which new technologies only complement. Where it is employed, IV has broken ground for new ideas in many organizations, and is providing cost-effective services of many kinds.

Few people have made a fortune through IV, and some have lost a packet, but many are quietly doing well. Multimedia has captured the imagination of the industry itself, but many corporate clients are just settling in to realize the benefits of their investment in IV, and are not anxious for change. Ultimately, it is not the technology, so much as the management and communication skills with which it is applied, that make the difference. Most successful projects use technology-based systems together with other forms of communication, from classroom instruction to printed brochures.

The threat of 'format wars', too, is often raised in discussions of CDTV and CD-I for the consumer market, or CD-I and DVI in the corporate sector. One anthropological view of the multimedia market of the early nineties characterized the two camps in ethnographic terms, as CD-ROMANS, with the 'CD-I couch potato TV clan' shaking its spears at the 'DVI hacker PC workstation clan', and MPEG as a power base. In this interpretation, agreements between Philips, Sony and Matsushita are the principal dynastic alliances in the CD-I clan, as are agreements between IBM and Intel in the DVI clan. The many other organizations attracted to the fold subsequently become 'unattached males, roaming around trying to decide what family to marry into.'[5]

Another observer takes an equally ironic view of the DVI/CD-I issue: 'We are trying to compare an apple and an orange in the bush, with a bird in the hand.'[6]

DVI technology aims to establish a standard feature for desktop computers, and is not engaged with larger issues such as standard file formats or conventions for user interface. CD-I is a complete system with its own fat *Green Book* to lay down every detail of the hardware and software platform from 'base case' functional specifications to protocols for screen displays and user interface. It was designed primarily for the home, and aims to establish a *de facto* standard for consumer products. In professional environments, CD-I is not primarily a peripheral device for established networks, but offers a standalone system for dedicated training, marketing or information services.

What is important to remember in any discussion of new platforms and products is that much of the enthusiasm for the new – and consequent disdain for the old – comes from technophiles impatient for change and indifferent to practical constraints.

Technology changes faster than attitudes, and the forces which govern change in consumer markets and corporate environments are subject to many practical restraints – from the capital cost of new equipment to the difficulty of introducing, implementing and evaluating new practices.

Enthusiasts also might consider the judgement passed by one old IV hand even as CDTV, CD-I and DVI technology were at last reaching the professional market: 'It's only multimedia to the developer. To the average user, it's a lot like one medium – television. To the people who have been staring at a C prompt for the last few years, multimedia looks great. But as yet, it doesn't look as great to the video-trained eyes of the interactive video industry. You don't have to be a video professional to know good video when you see it.'[7]

One of the most seasoned veterans of the entire campaign, the editor of *The Multimedia and Videodisc Monitor* (est. 1983), Rockley Miller, proposed one more standard in his editorial of November 1990: E-Motion. He observed that 'all our personal input devices are analogue ... and all our experience is linear' and suggests that 'E-Motion begins by promising and ends up delivering (now, get this) a satisfying and complete linear analogue experience.' The foundation of that platform is not technology, but human communications.

Notes

1 What is this thing called 'Magilla'?, *The Videodisc Monitor*, July–August 1990.
2 Neil Sandford, The Soft Option, relaying an observation made at the Seventh Annual Nebraska Videodisc Symposium in *Interactive Update*, July/August 1989.
3 Trevor Wing, VideoLogic, speaking at CD-ROM Europe '91, London, 21–23 May 1991.
4 Scott Brownstein, Consumer Imaging Division, Eastman Kodak, speaking at Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.
5 Chad McDaniel, Academic Software Development Group, speaking at Microsoft's Fifth International CD-ROM Conference and Expo, San Francisco, 27 February–1 March 1990.
6 Jim Hoekema, Getting Sensible about CD-I and DVI, *The Videodisc Monitor*, November 1990.
7 Mark Magel, Matching Multimedia to the Medium, *The Videodisc Monitor*, May 1990.

3

Multimedia titles

This chapter describes typical applications of the various multimedia platforms described in Chapter 2. This includes a sample of titles from the consumer market, and brief descriptions of professional applications in education, training, marketing, public information and tourism. The applications have been selected to provide an overview of applications and market trends, and to suggest the kind of topics and design ideas which might be exploited on virtually any multimedia platform.

CD-DA

As a product for home entertainment, CD-DA has proved equally popular with young pop music fans, and older audiences with tastes such as classical music or jazz – the very target audiences, with special interests and disposable income, at whom multimedia products are particularly aimed.

The CD's features and benefits were easily appreciated by comparison with conventional audio products – which is all to the good for the next generation of multimedia systems. The familiarity of the compact disc itself makes the business of launching new CD products that much easier. The introduction of both CD-I and CDTV to the consumer market emphasize their affinity to CD-DA, rather than computers. Audio disc products also enjoy a glossy upmarket image, which CD-I at least is likely to share.

Once established on the consumer market, CD-DA began to penetrate professional sectors. Its salient features – small size, large capacity, instant random access, and resistance to wear and tear – are ideally suited to jukeboxes and the closed-circuit broadcast systems which supply light music to factories, foyers or shopping malls

(sometimes, in conjunction with satellite broadcasting). Some jukebox systems also include advertising: with tighter restrictions on the promotion of cigarettes and alcohol, for example, schemes such as the British PopNet service pitch ads of this kind to target audiences through jukeboxes in pubs and clubs. The potential for audio-visual jukeboxes is obvious, and already exploited by LaserDisc and DVI applications described below.

In training applications, an extra CD-DA drive can also provide additional sound to accompany computer screens or video segments. Equally, the CD-DA audio disc can be read from a CD-ROM data storage drive, so one delivery system can often present information from both kinds of disc. As CD-ROM drives become more common in the workplace, the enhancement of computer-based training with the excellent audio of a CD is another area ripe for exploitation in subjects which need no more than sound, text and computer graphics.

Interactive video was entirely new, and is still difficult to explain to people unfamiliar with technology-based training or interactive information systems. CD-I, and other multimedia products for the consumer market, enjoy the great advantage of following a highly successful product into a market where it is now widely used and appreciated. The success of the compact audio disc in the consumer market, and awareness of CD-DA in professional environments, has prepared both sectors for the next generation of compact disc products.

CD-DA is also paving the way for multimedia applications with the 'ready' discs, described more fully in Chapter 6, CD-I Discs and Drives. The first of these was released by PolyGram in 1991: *Louis Armstrong – An American Songbook* provides a complete recording for the CD-DA system, but also contains a variety of other textual and pictorial information for display on a CD-I player, which will instantly add value to the disc when users upgrade.

CD-ROM

CD-ROM is used primarily for large databases in professional markets such as finance, medicine and the law. From a handful of titles in the mid-eighties, TFPL's international catalogue, *The CD-ROM Directory*, grew to list some 1522 titles in 1991. However, as this represents work in several national languages and computer platforms, the choice of titles available to any one market alone is somewhat smaller than the total number suggests.

Aside from commercial publishing, CD-ROM is used by many organizations to store records for private use or limited distribution. A single disc can be produced for a few hundred pounds or dollars, and a small run can be much cheaper than equivalent printing costs for literature which could be much less easy to use. Many companies offer low-volume replication facilities, and the necessary equipment can also be installed in-house where the volume of data processing is high enough, or absolute confidentiality is essential.

The versatility of CD-ROM has also been exploited in a variety of projects which point the way to large-volume multimedia applications. For example:

- The US Defense Mapping Agency undertook a two-year project in spring 1990 to produce *The Digital Chart of the World.* At a scale of 1:1000, the land surface of the entire globe will be charted on some 25 or 30 CD-ROM discs.
- The European Patent Office in Munich now publishes 50 000 CD-ROM discs in place of 150 000 000 printed pages. The Patent Office produces enough data to fill two new discs a week.
- CD-ROM provides the medium for two in-car navigation systems in Japan. A built-in disc-based navigational system is now standard in the top ranges of the Japanese automotive market.
- *Arctic Data Interactive* is an electronic multimedia science journal published on CD-ROM, with text, animation and satellite images. It uses hypermedia retrieval techniques to allow readers free access to all the data on the disc.
- The international ADONIS project stores abstracts and articles from bio-medical journals on CD-ROM. In the British Library, a CD-ROM jukebox from Next Technology of Cambridge offers rapid access to data from over 100 discs, and supports several workstations simultaneously. Next's Voyager jukebox supports up to 270 discs and eight drives (some 175 000MB or 80 million pages of data) in a jukebox which can sit under an office desk.
- *Antics and Semantics*, made for British Rail in 1988 by VideoMedia, combined a laser videodisc with a CD-ROM drive for data storage, CD-DA audio for complementary soundtracks, and an audio digitizing card to record trainees' own input on the computer's hard disk. The target audience for this complex package were systems analysts within BR's own computer services, a highly computer-literate group.

Although the cost of producing CD-ROM discs may be relatively low by comparison to other media, these purpose-built systems are not inexpensive. Equally, the price of

some commercial CD-ROM titles is shocking to those unused to the economics of professional publishing. One thing to bear in mind is that, for its small size, a single disc may still hold as much information as a private library. Another is that the single disc, which the buyer can use day and night as a private 'off-line' database, is often the only alternative to a live 'on-line' database which costs its users serious money for every second that they are connected to it.

Aside from databases for niche markets, there are also a number of commercial titles available on CD-ROM. For example:

- *Compton's Multimedia Encyclopedia* combines 5000 articles from the 26-volume printed version, together with some 12 000 maps, charts, graphs and high-resolution images. On a network, one disc supports simultaneous access from several computers. The package was released in 1989, and 250 American schools ordered over 1000 copies in its first month on the market.
- Ghost stories and children's stories are the subjects of the first anthologies from Canglobal Media Production Group. The discs each contain some 500 stories, with retrieval facilities including author, title, date, keyword and phonetic searching (when users only remember what a name 'sounds like').
- Other general reference works include the *Guinness Disc of Records* from Mirrorsoft, and the *Grolier Electronic Encyclopedia* (on which the multimedia version, described in Chapter 5, Designing for Interactivity, is based). In Italy, where publishers have taken enthusiastically to CD-ROM, the *Encyclopedia Elltronico Struttutato* is aimed at a CD-ROM consumer market which was developed by many of the same selling techniques as the home market for printed encyclopediae.
- Philips Interactive Media Systems launched the *European Business Guide* in 1991, as a compendium of information on travel and leisure for professional markets. The *Guide* includes visa and passport regulations, currency exchange rates, addresses for embassies and travel services, and timetables for airlines and trains. It also includes information on hotels, restaurants and leisure facilities, and emergency telephone numbers. One disc supports English, French, German, Spanish, Italian and Dutch, and includes a detailed list of contents, and keyword searches. Discs can be purchased individually, or as a subscription with six-monthly updates. The package won Best Consumer Application at the first European Multimedia Awards in Wiesbaden in October 1991.
- The UK Post Office publishes complete data for every postal address in the United Kingdom on a single disc.

- The National Portrait Gallery in Washington DC, used CD-ROM to store some 3000 portraits on one disc.
- *Svinga, A Multimedia Journey Through Zimbabwe*, includes 45 minutes of music, 1000 maps and pictures of flora, fauna, parks, archaeological sites, cities, towns and villages, biographies, and profiles of 7 500 companies in the African nation. Media Technology of Zimbabwe went on to produce a visitors' guide to a dozen countries in *Southern Africa Tourism CD-ROM*.
- DC Comics have also tested the water with *Digital Justice*, a Batman comic on CD-ROM, with computer graphics, animation, music, voices, sound effects and background material on characters in the Batworld.
- ICOM Simulations produced a game with some 90 minutes of partial-motion video (at 15 frames per second) in *Sherlock Holmes – Consulting Detective*, developed on CD-ROM for no less than five computer games platforms (NEC's PC Engine and Turbo Grafx-16, Fujitsu's FM Towns, IBM and compatible PCs, Apple Macintosh computers and Commodore's CDTV).

Altogether, from some 54 CD-ROM titles in circulation in 1986, Infotech identified 2250 by 1990, and the market is clearly growing apace.

LASERDISCS

LaserVision was first offered to the consumer market in Japan and the US in the late seventies, and Europe in the early eighties. Discs had considerable success in Japan (outstripping videotape sales by 1990), less in America and virtually none in Europe. But Pioneer re-launched LaserDisc in America in 1989, with $500 players, a good choice of discs for sale, and the support of video rental outlets: some 2.5 million discs were sold in the US that year. The popularity of 'Laser Karaoke' sing-along systems in pubs and clubs has also revived interest in LaserDisc in Europe and the US.

LaserDiscs for the consumer market principally offer film classics, recent releases and music videos. Many video rental shops offer discs at the same price as tapes, and mail order services cater for fans who want to own high-quality recordings of their favourite shows. Some simple interactive programmes were released even in the early eighties, and some are still as entertaining as many new multimedia titles. However, neither the disc nor low-level interactivity caught on (not the least because of the complexities of early keypads and retrieval systems), and the market now favours high-quality linear video.

However, educators were quick to recognize the value of 'resource discs' which provide an economical and hard-wearing alternative to videotape, and a rich source of material for teachers' and students' own multimedia presentations. With no co-ordination on a federal level, the installed base of LaserDisc players in American schools is patchy, although some states have taken significant initiatives. Various European governments have sponsored nationwide projects, but the installed base of players as a whole is still small. Nonetheless, American publishers including Encyclopedia Britannica have begun to transfer their libraries from videotape to disc, and a double-sided disc often costs less than the equivalent videotapes.

In all markets, videodiscs have the oblique advantage of presenting less temptation to those who pilfer recordable videotapes for re-sale or re-use.

INTERACTIVE VIDEO (IV)

Interactive video is used primarily in marketing, training and education in corporate, industrial, professional and institutional environments.

In training, interactive video was originally the province of large organizations which could afford to make their own programmes. Now that several hundred 'generic' titles have been published, IV is a cost-effective option for small companies, which can purchase or hire both hardware and software – usually, much more economically than running a course in-house or meeting all the costs of sending employees to external training centres.[1]

- *IV, like corporate video, makes extensive use of drama, both to provide good role models, and to allow trainees to explore the consequences of various types of behaviour in realistic but non-threatening situations.* The Talent Series from Interactive Information Systems (IIS), for example, creates a typical workplace for each programme, so that trainees can follow a cast of characters through many related scenes, and absorb some implicit lessons in human communication skills along with overt instruction in office procedure or sales techniques.
- *The variety of visual images, and rapid access to information from any part of the programme, also makes IV a good choice for technical training.* Users can examine objects and processes in great detail, and manipulate video images in slow motion or elapsed time. Using the keyboard, they can also supply exact answers to test questions where a high degree of accuracy or discrimination is required. Jaguar Cars effected considerable savings of time and money by using

IV to provide both training and reference material for technicians in their international dealer network. Ford of Europe commissioned a package on *Statistical Process Control (SPC)* from Futuremedia, for their factories and suppliers, which now sells internationally as a published programme.

- *The combination of data from the computer and audio-visual information from the videodisc also makes IV a good medium for training in scientific and financial sectors.* Volumes of dry textual or numerical data can be enhanced with sound and pictures, tutorials and examples of realistic applications. The medical, nursing and veterinary schools of several European and North American universities and teaching hospitals have produced IV packages for their own use, and commercial distribution to other institutions.

The same features have made IV popular in education, although the relatively high initial cost of the delivery system, and a lack of central co-ordination, has inhibited the growth of this market. As IV has no single standard for hardware or software, no one system can run all the educational and training material which schools, colleges and businesses might use (which a CD-I system could, of course).

- *Successful applications of IV have included simulations of lab experiments, dramas which apply mathematics to daily problems, and social studies projects which allow students to collect and analyse data from an audio-visual record of a real environment.* Typical titles include *Chemistry at Work* from Videodiscovery and McGraw-Hill in the US, *Risk and Probability* from the University of Newcastle-upon-Tyne's Interactive Learning Project, and *Community Snapshot* from the Toronto Urban Studies Centre's Street Work Division. In 1990, IV was chosen for tuition in secondary mathematics in British schools, with discs produced by New Media and Evergreen.
- In education as in training, IV can provide a range of support material – optional sub-titles, dictionaries and glossaries, reference material, remedial sequences, even calculators – which may appear automatically when users flounder, or which can be called upon as required.

IV is also used in a variety of marketing applications and public information systems, from city guides in tourist centres to store guides in shopping malls.

- *An interactive video catalogue is appropriate both to product ranges which are too large to be displayed in any one outlet, and products which are too complex to be demonstrated easily in a shop.* In the US, Florsheim Shoes use IV in 500 of

their own shops and in selected Sears Roebuck stores to supplement the relatively small display of products in any one site with information on all the designs, colours, materials and sizes available. The 'transactional system' even processes customers' orders for delivery to their homes. Also in the US, the Central Hardware chain reached one million customers in less than a year with IV systems in 38 stores. They provided do-it-yourself video clips, together with a printed summary of instructions, a store directory, and coupons for weekly special offers.

- *For travellers planning a holiday, or visitors in a new place, interactive brochures and guides combine the impact of video with the practical functions of a database.* A number of systems for American travel agents combine travelogues with hotel and travel information, and subsidize the cost to agencies with advertising on the disc. In busy environments, the system keeps waiting customers engaged, and provides much of the information they need, so that staff can concentrate on special services, and closing the sale.
- *Interactive video is also used by museums, galleries and commercial exhibitions to provide electronic catalogues to works in the collection (as in the National Galleries of the US and the UK), or gallery guides (such as those in Smithsonian museum complex in Washington DC).* The same material can also be adapted to IV or CD-I for sale to consumer and educational markets.
- *IV can also provide challenging insights into museum collections. The Living Arctic* was produced by New Media for Indigenous Survival International, for the Museum of Mankind in London and the Canadian Museum of Civilization. It uses stories and games to illustrate realities of modern life in the north – and, unusually for an ethnographic project, has been seen by thousands of the people whose lives it describes, in a touring exhibition organized by the Canadian Secretary of State's Department. *Collectors in the South Pacific*, made by New Media for the City of Birmingham Museum (UK), examines artifacts from the different perspectives of a missionary, a tourist, a curator and the collector himself.

Two audio tracks are particularly useful in interactive video programmes, where one may store the sound which accompanies the video, while the other provides additional commentary or sound effects for screens of text and graphics supplied by the computer. The two tracks may also carry complementary soundtracks for two versions of the same video sequence.

- *In many subjects, the separate use of the two audio tracks provides extra tuition and some welcome diversion from many screens of complex data.* In financial

training produced by Price Waterhouse and Premiere Productions, one audio track accompanies the video on the disc, the other supplements graphics from the floppies. With this extra audio, one double-sided videodisc and a couple of floppies can support up to 10 hours of training.

- *Separate audio tracks are also useful in providing two spoken responses for a single video scene.* In some of Jaguar's programmes, for example, the same image appears after a test question, whether the trainee's response was right or wrong. One track begins 'Well done, that's correct!' and directs users to the next segment. The other track indicates that another answer would have been better, and directs the trainee to a remedial sequence.
- *In a typical 'keep fit' programme for the home video market, one track provides encouragement from the instructor, while the other simply supplies music for those who can follow the routine without advice.*

Similar principles can be extended to provide separate commentary in two or more languages, or from different perspectives (say, clerical staff and their managers). However, the use of multiple audio tracks – with as many as 16 at a time in CD-I – demands skill from the writer, actors or voice-over artists, to ensure that complementary audio sequences always fit the video or graphics which accompany them. Creative skills are always as important as technical competence.

The critics of interactive video feel that IV should have penetrated far deeper into many, wider markets. But there are literally thousands of IV applications, current and historic, all over the world. The main markets are in Japan, the United States and Canada, and western Europe, but odd applications have emerged from Southern Africa to China. Many IV projects were expensive lessons to their developers, but many are also dramatically cost-effective and efficient. But the technology alone cannot make a team work well together, or solve a problem which depends on human communications: the projects which have been most successful typically display a sound implementation strategy both to introduce the new system, and support it.

DVI TECHNOLOGY

DVI technology is being used to create multimedia programmes in training and education without the encumbrance of IV delivery systems (or the volume of full-motion, full-screen, broadcast-quality video images which LaserDiscs provide).

- One of the very first applications of DVI technology was made for industrial training by Bethlehem Steel and Lehigh University. Training projects in other sectors include crisis management in the oil industry, group dynamics for software engineers, and a video-and-text database for railway engineers.
- The first commercial training application in the US was TDS, a simulator for safety training in tractor-trailers and tank trucks, developed by Du Pont and Applied Optical Media Corporation (AOMC) in the autumn of 1988.
- One of the first applications of DVI technology to existing materials was undertaken for the UK Training Agency by ICL and New Media, who adapted management training on *Quality Assurance* for distribution to executives in small and medium-sized companies. In Germany, 3V Multimedia undertook a similar project to adapt technical training material for the national telecom.
- A training course for pilots on the DeHavilland DASH 8 commuter plane uses DVI technology with a touchscreen delivery system. The package, produced by FlightSafety and Jay Silver Productions, also provides hyperlinks from the training programme to a 300-page flight manual. Royal Dutch Airlines has also applied DVI technology to training mechanics in cabin maintenance (in a package produced by Mediavision), and British Rail commissioned a desktop simulator for train drivers from Hodos. Nixdorf Computer and Clarinet Systems have developed a generic workstation which incorporates DVI technology for training and information in the motor industry.
- The inside of the plane is the setting for *El Avion Español*, created by the Interactive Multimedia Group at Cornell University for intermediate-level Spanish studies. The student is cast as a journalist who is preparing an article about a commercial airline flight. Conversational and social skills are both employed to 'meet' and 'interview' fellow passengers.
- In France, ACT Informatique applied DVI video to a simulator for training in endoscopy, and Modern Information Technology developed a pilot programme on automotive mechanics for BMW in Germany. Banque Nationale de Paris uses DVI technology to support linear video training from desktop computers.
- In the UK, ICL and Attica Cybernetics applied DVI video in a demonstration package for science teaching in schools. In higher education, DVI technology is used by the US Educational Testing Service for professional certification.

DVI technology also provides an alternative to conventional information services. Some of the first clients included a German pharmaceutical company, a German retailer, a Spanish confectioner, and a travel agent and a bank in the Netherlands.

- The public information systems in Paris' Charles de Gaulle airport are supported by DVI technology, in a project developed by Xis. In Germany, BMW have experimented with a DVI-based system at their own management training centre. Olivetti, one of the companies involved in the development of the technology, have used it in a presentation system for exhibitions.
- The first commercial application of DVI technology to public information in the US was undertaken for tourist centres and rest stops along the Florida turnpike in 1990. *Florida TouchGuide*, developed by Intelex and National Technology Corporation, provides information on attractions and services (including hotels and restaurants) in the sunshine state. It includes a printer for data and directions to guide visitors from the tourist centre to the sights of their choice. The developers created portable versions to help to promote the concept and sell advertising.
- DataEast are producing arcade games on CD-ROM with DVI technology. A prototype of the first, *Thunderstorm*, was shown in Japan in October 1990.

Through DVI technology, the addition of video transforms what are essentially textual databases into a range of new products for many markets.

- Ace Genius is a pub, club and arcade game developed by Ace Coin Equipment (a subsidiary of Allied Breweries). The trivia quiz includes 12 000 multiple-choice questions, 6000 still images and 400 video clips, as well as audio clips and animation including an attractor loop which plays when the system is idle. The developers are selling the interface board and development tools created for the package, to encourage other producers to create more software for this hungry market. (For more on games, see Chapter 4, Publishing Multimedia.)
- An electronic version of the *Basic Atlas of Cross-sectional Anatomy* employs DVI compression techniques to adapt a medical textbook to CD-ROM. The Bowman Gray School of Medicine and Gallaher Business Development worked with one of the authors of the book to enhance text and images with interactive navigational devices and audio. Rather than covering the screen with captions, users employ the computer's mouse to point-and-click at any part of an image to see a pop-up label.
- *Ulysses* is a resource base for the teaching of literature in schools, developed by AND Communications. It is based on Tennyson's dramatic monologue, but analyses both the poem and poet to illustrate how trends in literary criticism, and each reader's personal response, influence the interpretation of a work, and to explore the role of poetry and literature in society.

DVI technology also supports true visual database and imaging systems.

- An image base of some 2000 photographs from the Uniphoto Picture Agency is the first in a projected library of multimedia resource discs from Applied Optical Media Corporation (AOMC). The inaugural package used DVI technology to store images at 512x480 resolution on a CD-ROM disc, but AOMC plan to provide material in the Mediasource series on a variety of platforms. Photobase was announced in spring 1990, at a retail price of $395.
- Barcelona's Hospital de Esperanta uses DVI image processing in a multimedia database developed by Visualsoft to link X-rays and other visual data with doctors' notes and patients' files.
- Jersey Museum in the Channel Islands used DVI technology to store some 1000 photographs, 30 minutes of film and video, and 1500 screens of text and graphics in a presentation which could run for over eight hours from a single CD-ROM disc.

A variety of projects use DVI technology in archives and telecommunications.

- DVI technology has been applied to interactive movies by the MIT Media Lab, to telecommunications systems by Alcatel STK, to military intelligence by Betac Corporation, and to use in space travel by McDonnell Douglas Space Systems.
- In another innovative application of technologies, Aiwa have employed DVI compression techniques to record animation on digital audio tape (DAT), the format which offers CD-DA quality sound on a recordable tape. A two-hour DAT cassette can hold up to 1400 still images, or two hours of animation.

DVI technology is clearly not a single commercial product, but a process which facilitates the development of multimedia programmes in a variety of professional environments, on many hardware platforms.

DESKTOP VIDEO

With the rapid convergence of products for the professional computer market, it may soon be difficult (and pointless) to distinguish desktop video from computer-based training and information at large. Some important initiatives have been undertaken by the very companies with products in this market.

- IBM's own Multimedia Learning System is used for training within the network of authorized personal computer dealers who distribute IBM's products. It is

important that these dealers receive the same quality of training as IBM's own staff, and interactive video has been used since the mid-eighties in IBM dealerships internationally. The upgrade to multimedia combines an IBM PS/2 computer with CD-ROM drive, a Pioneer videodisc player, and IBM's M/Motion Video Adapter/A card.

- The National Geographic Society used IBM's AVC card and LinkWay software to create moving footage in *Mammals: A Multimedia Encyclopedia*, in autumn 1990. Motion is restricted to a window in one quarter of the screen, and frames rates of 10 to 15 per second, but is processed entirely within a standard IBM PS/2 computer, with no additional hardware in the delivery system. The programme includes 700 full-screen photographs with captions, 600 pages of text, 155 audio clips of 'animal vocalizations', 150 maps, 45 clips of moving footage from National Geographic documentaries, and a range of statistics and other data, for use in libraries, schools and homes. It was launched in the US at $150 (retail) and $99 (education).
- Commodore Business Machines and the Institute for the Transfer of Technology to Education (ITTE) launched a grant scheme in the summer of 1989 to assist 20 schools to develop desktop video applications for the classroom. Each school was given an Amiga 2000 and a two-day preparatory course.

The success of these initiatives will truly be proved when desktop video ceases to be a niche in the professional computer market, and becomes a standard feature.

CDTV

CDTV was released in the spring of 1991 with a small catalogue of titles which neatly represented the main trends in software development for the consumer market. Consumers who responded to the advertising campaign were sent lists of titles with a release schedule, to assure them that, although only two dozen discs appeared on the shelves alongside the machines, more would follow. By the autumn of 1991, Commodore reported that some 380 developers worldwide were working on CDTV titles, and over 200 would be in circulation within the year.

In the UK, most of the packages were released at prices between £30 and £40, putting them on a par with computer games or glossy books. Some few reference packages (such as an atlas, and *Dr. Wellman*, the family health guide) topped the list at £55 – a large premium for their interactive features, by comparison to printed books

on the same subjects. In the US, most prices ran between $40 and $80, but for the *Grolier Electronic Encyclopedia* at $395 (not then launched in the UK).

Meanwhile, independent dealers were asked to join Commodore for a training course on CDTV before undertaking to promote the product, and cautioned to display the system at least four metres away from computer goods – indeed, never to mention the 'c' word in the same breath as CDTV.

The first packages included games for adults and children, teach-yourself packages, and publications for recreation and entertainment.

- *All Dogs Go to Heaven Talking Electric Crayon* (developed by Merit Software from a popular animated film) and *Animated Colour Book* (from Gold Disk) allow children to 'colour' pictures by selecting 'crayons' to fill shapes within drawings on the screen. The child's choice of colours stays with the image as it is animated to a musical soundtrack. *My Paint* is a computer graphics package for children, developed by Saddleback Graphics.
- Stories such as *A Bun for Barney* (about a little bear who learns to say 'no'), *Barney Bear Goes to School* and *Fun School 3*, combine stories, games, lessons and a chance to develop reading, hand-eye co-ordination and other early learning skills; the packages were made by MultiMedia Corporation, Free Spirit Software and Database Educational Software respectively. Other story books have been adapted by Discis from classic and modern favourites including *The Tale of Peter Rabbit* and *Scary Poems for Rotten Kids*.
- *Our House* (from Con-Text Systems) offers an offbeat look at common household objects which shows young children how they work today, and what similar objects did in family homes of the past.

The initial range of CDTV games is virtually a market research report in itself, with something for every niche in the computer games market, in all its permutations:

- *BAT, Bureau of Astral Troubleshooters* (sci fi fantasy), *The Case of the Cautious Condor* (art deco thriller), *Defender of the Crown* (Robin Hood *cum* Ivanhoe), *Falcon F-16* (top guns), *Future Wars* (alien invaders), *The Hound of the Baskervilles* (Sherlock Holmes), *Psycho Killer* (made-for-CDTV slasher), *Snoopy: The Case of the Missing Blanket* (cartoon fun), *Spirit of Excalibur* (swords'n'sorcery), *Unreal* (Gothic fantasy) and *Wrath of the Demon* (he-men vs. forces of darkness).
- Other games include screen versions of *Pro Tennis Tour II, Battle Chess* and *Classic Board Games* (chess, checkers and backgammon), as well as adaptations

of best-sellers for home computers (such as *Sim City*, one of the few home entertainment products based on the challenges of urban planning) and for interactive videodisc (*Murder, Anyone?*, first released on LaserVision in 1982, *Many Roads to Murder*, launched in 1983).

Some programmes combine light entertainment with personal development.

- In *Music Maker*, developed by Ariadne, users can 'play' any of 40 instruments on 17 tracks.
- *Mind Run* presents a series of aptitude tests and challenges to evaluate and improve memory and listening skills, logic, reflexes, the ability to handle stress, and understand machines.

Although CDTV is primarily a consumer product, some of its first software packages, and marketing initiatives, also support formal education.

- *LTV English*, from Jeriko, is a transatlantic package set in London and Los Angeles, to help people who are learning English as a second language by presenting scenes of daily life in two cities and a range of accents and cultural indicators.
- *Gardenfax* is a four-part series of information and advice for gardeners, on *Indoor Plants, Garden Plants, Fruits, vegetables and herbs* and *Trees, shrubs, roses and conifers*. The project was originally developed for interactive video on a single LaserVision disc by Intersearch Systems; the four CDTV discs cover from 170 to over 400 plants each. Search criteria allow users to specify both desirable features (such as height and colour), and local conditions (such as soil type and light aspect) to find plants which will suit their gardens horticulturally and aesthetically.
- A pilot project in 120 British schools began in 1990, with Global Learning Systems of Derby. The first CDTV package addressed Japanese language and culture, just as Toyota started to build a new factory in Derbyshire.

CDTV also, of course, provides reference material for general use and special interests.

- *Crisis in the Gulf*, the first in a project series of *Advanced Military Systems* (developed by Dominion with over 1500 action shots of military hardware) and *Women in Motion* and *Animals in Motion* (from On-Line, based on the still photography of Eadweard Muybridge) are effectively interactive 'coffee table books'.

- *The Dr. Wellman Family Health Adviser* (developed by Digita Multimedia) covers everything from first aid and foreign travel to substance abuse and 'password-protected sections dealing with Adult health'. Its 'script' comprises a 400 000 word book, written specifically for the project and divided into 4000 data files, which is enhanced with 1 300 illustrations, 10 hours of audio commentary, an hour of music, and sound effects.
- 'Timetables' of *Science and Innovation* and *Business, Politics and Media* (from Xïphas) combine a timeline of critical events with background stories, quotes, illustrations and reproductions of documents.
- There are also Xïphas' electronic versions of the popular *New Basics Cookbook* and *American Heritage Illustrated Encyclopedic Dictionary* (with keyword searches for compound words, and aids for pronouncement), New Media's *Guinness CDTV Disc of Records*, Animated Pixels' *Illustrated Holy Bible* (with keyword search and bookmark), *World Vista Atlas* (based on Rand McNally's *World Facts and Maps* by Applied Optical Media), and the *Complete Works of Shakespeare* (developed by Animated Pixels with a concordance, keyword search, bookmark, woodcut illustrations and illustrated *dramatis personae* for each play).

Titles in production at the time of the launch followed a similar pattern, concentrating on children's activity programmes, and an array of games for children and adults, with a few more music discs and general reference works.

CD-ROM XA

CD-ROM XA, like desktop video, is less a platform than an interim product in a rapidly-developing market. Nonetheless, extended architecture has supported some innovative projects.

- The first professional application of CD-ROM XA was completed in the spring of 1990, by Bermac, as a training course for TetraPak. The package combines CD-ROM XA and a videodisc in the Sony VIEW, a proprietary delivery system. The CD provides text and commentary in 12 languages, to train operatives in the company's international group of packaging factories.
- The American Library of Congress is employing a variety of multimedia platforms in its American Memory project. Interactive Arts employed

CD-ROM XA digital audio in a three-hour collection of speeches and other recordings from 1918-1920 called *The Nation's Forum.*

- In marketing, *Music City Data* is a 'preview' programme for Japanese record stores, produced by CBS and Sony, with a combination of computer animation, full-motion video, and a text database. Preview programmes are a persuasive variation on the listening booths of yore, combining information about popular artists and releases with extracts from the recordings.
- In the UK, the Training Agency provided government funds for nearly half the £400 000 used to develop a four-part CD-ROM XA package on adult literacy, *The Reading Disc*. The multi-cultural programme was produced by Next Technology and Cambridge Training and Development for use in open learning centres.
- British Telecom's Distance Learning Unit, one of the first to exploit interactive video, was equally quick to commission two training packages on CD-ROM XA from Xebec Multimedia Solutions. *Telephone Techniques* can be used by staff at all levels; *The Business Management Programme* is designed for senior executives, and combines IV with CD-ROM XA in one of the first multimedia packages to be accredited toward a Diploma in Business Management.

The Reading Disc and *Telephone Techniques* won Best Education Achievement and Best Corporate/Business Application, respectively, at the first European Multimedia Awards in Wiesbaden in October 1991.

The CD-ROM XA bridge to CD-I means that some XA titles could run on CD-I delivery systems, or be enhanced with the full range of CD-I features.

CD-I TITLES FOR THE CONSUMER MARKET

This section briefly describes some of the programmes for the CD-I consumer market which were designed for release alongside the player, or soon after.

Most of the first releases for CD-I are co-produced by Philips Interactive Media of America (PIMA), the organization which provides a forum for multimedia publishers, designers and producers. PIMA is a subsidiary of PolyGram (itself a subsidiary of Philips), so PIMA's role in software development is analogous to Philips' role on the hardware side.

The easy way into interactivity for many consumers will be through CD-I discs which complement full-length audio recordings with text and pictures which range from extended liner notes to comprehensive biographies.

- *Classical Jukebox*, *Golden Oldies Jukebox* and *Cool Oldies Jukebox* (Interactive Production Associates/PIMA) are compilations which use CD-I's choice of audio levels to store over 100 minutes of music on each disc. *Classical* features a listener's guide to the 'pops' end of the classical repertoire and notes on famous composers, while the *Oldies* complement the popular music of recent decades with images of the era, facts about the songs and their performers, and a trivia quiz.
- *Frank Sinatra: My Father* (Interactive Production Associates/PIMA) is based on a book by Nancy Sinatra. In one neat application of interactivity to conventional material, a portion of the biography is presented as questions and answers, so users can play at 'interviewing' ol' blue eyes. The package also includes a complete discography and list of performances.

Games on CD-I, if they are to exploit the potential of the medium, will be more expensive and demanding to produce than many games for the home computer market. Equally, the audience for CD-I games may be older and more upmarket than the established audience for computer games. Thus, the first range of CD-I games inclines toward old favourites, and the adult end of the market.

- There will, of course, be CD-I versions of familiar board games, including *Backgammon, Battleship* and *Pinball* (Capitol Disc Interactive/PIMA), *Clue* (Parker Brothers/PIMA), *Jigsaw* and *Sargon Chess* (Spinnaker Software/PIMA). The chess package, for example includes tutorials and problem-solving exercises, replays and analyses of great games in chess history, as well as 45,000 moves and 16 levels of complexity from absolute beginners to grand masters.
- Games of the kind made familiar through arcades and home computers will be represented by CD-I versions of *Dark Castle* (a popular swords'n'sorcery package), *Déjà vu* (a detective thriller set in the forties), science fiction adventure in *Rocket Ranger* and *Space Lords*, and *Uninvited* (a supernatural thriller).
- The potential value of the entertainment market is reflected in the number of games being produced in a second wave of CD-I titles, which will follow those commissioned for release alongside the first players themselves. One company alone, Interactive World Productions (IWP) – a leading French computer games producer – put seven titles into production. They include a CD-I version of the popular *Sim City*, a board game based on *Asterix*, a quest game called *Marco Polo Jr.*, a kung-fu adventure (*Shaolin's Road*) and *The Mystery of Kether*.
- Another perspective from the world of adult games is provided by *Caesar's World of Gambling* from CD-I Systems/PIMA with Caesar's Palace in Las Vegas. The

disc simulates roulette, craps, blackjack, poker and five types of slot machines, and includes instructions for novices. Where a roulette or craps table is too complex to display on a single screen, users pan across the image, as though they were looking up and down the table in a real casino to survey all the options. Up to four people can play at one time, and the system stores cumulative records for up to 12 players. The disc includes tutorials and help routines, but uses no text whatsoever, so all prompts and instructions are provided by the spoken word, and all menus and icons are purely pictorial.

- Other CD-I games for grown-ups include *Hot Seat*, a party game with a 'Max Headroom-style' presenter and an array of social dilemmas to test players' tact, ingenuity and scruples.

Golf, the subject of many videotapes and computer games, leads the armchair sports.

- *Palm Springs Open* from Fathom Pictures simulates play on 18 holes photographed in some 7000 images on 18 world-famous courses. Two animated figures on the screen offer a choice of four positions and seven clubs. Players must compensate for random factors such as wind direction, and hazards such as trees, water and sand traps. Sound effects include pro commentary, and crowd noises from bystanders.
- *The Rules of Golf* was produced by Telecity CD-I with the Royal and Ancient Golf Club of St. Andrews and the US Golf Association; the disc comprises official rules, definitions of golfing terms, a guide to golfing etiquette, a quiz for one or more players, and a simulator which allows users to set up a critical situation and get a ruling drawn from some thousand actual examples.
- *Great British Golf*, adapted from interactive exhibits at the British Golf Museum by I Contact, includes a history of the game, a trivia quiz and a simulated round on the Old Course at St. Andrews.
- As well as a choice of other golf titles, other armchair sports include *Sporting News Baseball*, which puts players up to bat against two major league pitchers, *A Day at the Races* (complete with betting facilities) and *International Tennis Open*.

Golf is such a popular topic – and golfers represent such an attractive market of typical 'early adopters' – that Philips offer a Golfer's Package to clubs, sports centres and well-heeled enthusiasts, with a CD-I player, two golf discs (*Palm Springs Open* and *Golf Museum*), two 'bonus discs' to attract other users (a music jukebox and *Cartoon Jukebox*) for £999, with *The Rules of Golf* as an optional extra for £78.30. The package was launched with a year-long programme of demonstrations at 50 European clubs.

A number of packages for the children's market combine entertainment with educational material and activities which exploit CD-I interactive facilities.

- Perhaps the very first CD-I application of all was *Adventures O'Night*, produced as a pilot project with Query when Matsushita began to develop CD-I applications in 1986. Matsushita's Mikio Higashi describes the adventure programme as 'a child's world of dreams' to illustrate his view that CD-I is essentially 'a picture book with sound.'[2]
- *Mother Goose: Rhymes to Colour* and the children's songs of *Cartoon Jukebox* (PIMA) allow children to select colours for line drawings on the screen, which can then be animated to the accompaniment of popular rhymes and songs. *Cartoon Jukebox* also allows users to play with the soundtrack of a Dixieland jazz number, and hear one song in a choice of English, Spanish, French or chicken (yes, clucking birds). *Paintschool* is effectively a computer graphics paint package for children. In Japan, Query have also developed *A Child's Paint Box.*
- *Mother Goose: Hidden Shapes* combines animation and songs with picture-book illustrations in which children can develop skills of identification, association and recall by finding 'hidden' shapes within the coloured pictures.
- *Story Machine* provides comic strip backgrounds and music, to which children can add their own dialogue in 'balloon' captions. The strips can be recorded on videotape, while the disc is used again to create new stories.
- *Children's Musical Theatre* (Sonic Images/PIMA) is based on a popular TV series for four- to nine-year-olds, but adds three levels of interactivity to the passive presentation of animation and songs. In 'Songmaster' mode, children can hear four songs in a choice of classical, country or pop styles, and vary the choice of lyrics and animated character on the screen. 'Rehearsal' mode is effectively karaoke, with the lead vocal silenced so that the child can sing along. 'Studio' mode is a version of the 'music plus/minus one' recordings to which many musicians practise: children can add or delete individual instruments to hear the effect of this on the ensemble, or even play along in front of the screen.
- *A Visit to Sesame Street: Numbers* and *Letters* (Children's Television Workshop/ PIMA) and *Tell Me Why* (Interactive Production Associates/PIMA) are based respectively on the popular TV series for pre-schoolers, and the classic question-and-answer books. *(Sesame Street* won the Nebraska Videodisc Group's annual award for Best Consumer Achievement in 1991.) Another popular children's author has produced a CD-I guide to Busytown in *Richard Scarry's Best Neighbourhood Disc Ever.*

- *Noah's Ark, The Exodus, Bound for the Promised Land*, and *Jonah and the Big Fish* are the first in a series of *Children's Bible Stories* (Interlight Productions/PIMA) for children from 5 to 11. An animated version of the story is supported by the Biblical text in the King James and modern English translations, picture essays on related topics and Bible verses, 'Bible trivia' and activities including an interactive game, word study, jigsaws, connect-the-dots, a colouring book, and a form of karaoke sing-along.
- The *Children's Storybook* series includes *Pecos Bill, How the Camel Got His Hump* and *How the Rhino Got His Horn*, in discs which combine a story narrated by a popular actor (Robin William and Jack Nicholson read the first three), with activities that help to develop recall, comprehension and creative thinking. A 'Caregiver's Mode' lets adults guide children through the learning exercises.
- *Sandy's Circus Adventure* (PIMA) combines an interactive story, in which users decide 'what happens next', with games to encourage study and creativity, in the tale of a wild sea lion who joins the circus.
- *DinoVision* (PIMA) compiles clips from 'the 24-hour all dinosaur TV network', including the game show *Name That Dino* and the soap opera *The Young and the Reptilic*, as well as movie clips, news, music videos and advertisements, proving 'diversion of gargantuan proportions for saurians of all ages'.
- In May 1991, PIMA announced the licensing of the Nintendo® characters Donkey Kong®, Link™, Princess Zelda® and Super Mario®.
- Other CD-I games for children include *Classic X-Men* (Metrolight Studios/PIMA), based on a title from Marvel Comics.

Success itself becomes a problem for companies such as Nintendo, which became the world's leading games-maker – with a greater turnover than the whole of the French publishing industry[3] – and virtually saturated its target market in five years of rapid growth. CD-I represents an attractive opportunity to exploit the popularity of the concept with a new range of features, graphics and audio facilities; one pundit speculated, 'you could have a game which takes five years to play'.[4]

The first reference material for CD-I tends to be based on successful books, several of which have been greatly enhanced by the creative application of interactive features to conventional retrieval systems.

- *The Rand McNally Atlas of America's Riches* (Rand McNally/Videodisc Publishing/PIMA) is a classic 'cross-over' from a reference work to an armchair travelogue. It combines tours of every state with data on population, industry and

the economy, and a guide to tourist attractions, towns and cities. Like several other CD-I titles, it could be used in the classroom as well as the living room.

- *Treasures of the Smithsonian* (Smithsonian Institution/PIMA) combines armchair study and resource material for education and professional markets. It comprises a tour of 150 of the most popular exhibits in the 12 museums of the Smithsonian's complex in Washington DC. Interactive simulations allow users to view sculpture in the round, examine paintings, and hear instruments from a Stradivarius cello to an African thumb piano. Two hours of audio and 3000 images support over 100 hours of interactive study and entertainment.
- *Sexual Sphere* (Vortex Interactive/PIMA) is another cross-over, combining a self-help guide and a reference book, in a programme hosted by the popular American presenter Dr. Joyce Brothers.
- *Audubon's Birds of North America* provides bird lore, colour photos, descriptions, calls and songs, range maps, and data about habitats and behaviour patterns of some 125 species. In Japan, Dai Nippon Printing, Nippon Steel and the Wild Bird Society of Japan produced a guide to 60 species, with 250 photographs, 800 graphics, 70 minutes of audio, and 90 seconds of animation.
- One of the first professional publishing ventures on CD-I will adapt the 20-volume American *Textbook of Military Medicine* to a multimedia version with moving footage of combat surgery, and still images from the half-million 35mm slides of casualties and care taken during the Vietnam War.
- The German publishers Bertelsmann are considering CD-I for a series of publications, of which the first will be travel guides. These will be commissioned from production companies, but controlled by the publisher to ensure consistency in style and functionality. The guides are to be entirely self-contained, with instructions on the disc rather than in manuals. They will appeal both to armchair travellers and those planning real journeys, with a combination of passive video presentations and interactive databases. *Salzburg*, produced by New Media as a pilot for the project, was the first CD-I disc to allow users to scroll freely over maps larger than the screen itself, with hotspots following the action in any direction.
- The Dutch Book Publishers Association formed a consortium of six companies: Kluwer Boeken, Proclama, Spectrum, Tleeas, Tirion and Uniboek. With funding from the Dutch government, the group was conceived to organize workshops on CD-I, prepare a production manual, and publish a pilot disc. This will be a sampler, with material for the consumer market, on topics such as cooking, gardening, cars and teach-yourself language courses.

The widest cross-over market in CD-I lies in interactive reference and teach-yourself material. All the CD-I titles proposed so far involve a high degree of sheer entertainment; many also combine tutorials and advice for beginners with what amounts to reference manuals for those who are already familiar with the topic. Thus, many of the packages for recreation and hobbies are also reference tools.

- Sonic Images are developing the *Private Lessons Series*™ to provide interactive tuition on popular instruments. These will provide lessons at three levels from beginner to intermediate, and include features such as interactive duets in which students can take either part to practise alongside the tutor on the disc. The first volumes cover *Classical and Jazz Guitar* and *Rock and Blues Guitar*.
- PIMA's own ArtSpace group is producing a series of titles on Great Art, the first of which was adapted from a LaserDisc on Vincent Van Gogh. Their disc on Russian art features newly-discovered documentary footage from 1913, and fully 1000 hotspots initiating action on the disc.
- *The Urban Gardener* (Metrolight Studios/PIMA) includes tutorials, schematic drawings and reference material to help with the planning and maintenance of domestic gardens and landscaping.
- *Stamps: Windows on the World* (Glyn/Net/PIMA) is aimed at philatelists, but contains a wealth of visual source material for many other disciplines, including design and social studies.
- *Time-Life Photography* (Time-Life/PIMA) is based on a 10-volume part-work. A series of 25 workshops explain modern techniques for 35mm cameras, with simulated snaps to demonstrate the effect of different settings under the same conditions. The second part of the package, Photo Essay, combines great shots from the Time-Life photo library with commentary on their historical context.
- *Time-Life Astrology* offers an introduction to astrology, astrological insights into famous lives and instruction on casting and interpreting natal charts.

Many titles for educational and professional applications (such as language learning) are also likely to enjoy cross-over markets in consumer publishing.

CD-I APPLICATIONS IN PROFESSIONAL MARKETS

The appeal of CD-I in marketing and presentation aids was exploited as soon as developers could acquire the delivery systems.

- The first commercial application of CD-I was shown to the US Defense Communications Association's Forecast to Industry in Washington DC, in April 1990. The presentation was developed by Capitol Disc Interactive (a joint venture between Philips and Capitol Video Communications). It presented archival images of military communications from the past and present. The project was completed in 30 days, not as a showpiece of high-level interactivity, but as an implicit demonstration of the rapid progress of communications systems from carrier pigeons to interactive compact discs.
- The Principal Financial Group chose CD-I for a public information programme in the skywalk outside their headquarters in Des Moines, Iowa, and recommended the use of CD-I for internal training as well. The promotional programme, developed by Microwave Systems, describes the Group's products and services, its structure and marketing strategy. The touchscreen programme took four months and $40 000 to produce in the spring of 1990.[5]
- ICI Pharmaceuticals commissioned what is perhaps the first professional application of 'CD-I Ready' discs, from Epic Interactive Media, to support the launch of a new drug for the control of hypertension. *Zestril 24 Hour* provides material for use at conferences, exhibitions and other presentations by ICI's sales and marketing staff. It also holds a CD-DA recording of classical music so, with the relatively low cost of replicating compact discs, ICI's staff can give the disc to doctors and others in their target market to take home and play for pleasure. Should users then buy a CD-I player, they will find a multimedia information programme on the management of blood pressure on the same disc.
- The Paris metro commissioned an information programme for a new train line which will not have staff to answer travellers' queries in the station or on the platform. The project, developed by Interactif Delta, also has a promotional function in introducing the new line to the public, with 3D computer graphics to illustrate how sites under construction will eventually appear.
- *College Search* (American College Testing/Capitol Disc) helps students to evaluate institutions by criteria including location, academic and athletic programmes and religious denomination.
- CD-I Hotel Informer is a model for tourism, which combines information about attractions in Rome with an information package on the Byron Hotel, from its stately entrance through the piano bar and restaurant to features of its suites and bedrooms. The project is a co-production between Philips and Sigma (a joint venture of Alitalia, FS and Fintermica) in Italy.

CD-I was also chosen as a public information system by a number of museums before the system was released on the consumer market.

- The Flower and Green Expo in Osaka, which attracted some 20 million visits over six months in the summer of 1990, featured 26 CD-I systems scattered throughout the show, with presentations on *Fortune Telling*, *Songs and Flowers* and *10 000 Years of Flowers*. The *Flower and Green Library* and *Flower and Green Information* packages won awards in Audio Visual Age's Fifth Annual Grand Prix, organized under the auspices of the Japanese Ministry of International Trade and Industry. (Another award went to an environmentally-conscious children's game on CD-I, *Adventure of Spaceship Beagle).*
- Matsushita, one of the 20 hardware and software suppliers in the Flower and Green Expo, subsequently opened its own showroom, Tokyo P/N, where CD-I is demonstrated alongside other new electronics products.
- The British Golf Museum in St. Andrews, Scotland, uses LaserDisc and CD-I to support linear and interactive presentations . The programmes, produced by I Contact from scripts by the museum's Director, Peter Lewis, relate directly to the exhibits in each gallery. (A CD-I disc adapted for the consumer market is described above.) The museum originally featured slide projectors, installed by the interior designer 'against the advice of Philips and I Contact,' says Lewis, who observes 'We experienced more problems and down time with the projectors than with all of our optical disc players put together'; CD-I now supports the projection systems as well as interactive touchscreen terminals.[6]
- The Amparo Foundation of Mexico chose CD-I for a projected 30 information terminals while its new museum in Puebla was still under construction. The collection covers Mexican history from the pre-Columbian period to the Spanish conquest. Headphones and touchscreen terminals present displays tailored for each room of the museum. The programmes use a timeline to relate the displays to contemporary events in other cultures, and include games and other activities. The system provides commentary in Spanish, English, French and Japanese.
- The 1992 World's Fair in Seville saw the debut of *Quinientos años después (500 Years After)*, a project supported by the European Commission and the Sociedad Estatal Quinto Centenario to commemorate Columbus's voyage to the Americas. The multimedia presentation addresses historical and cultural links between Latin Europe and Latin America. As a consumer product for homes and schools, the disc is designed for use as a documentary programme and an interactive database, with commentary in Spanish, Portuguese, Italian and English.

- *The Sacred Way* will use photographic images of today's ruins and 3D computer graphics to provide reconstructions in an information system for visitors to the site of Eleusis, an ancient religious centre just west of Athens. The graphic reconstructions support a surrogate travel 'walk' through the site as it might have appeared 2500 years ago. The project is funded by the European Commission to provide a versatile package which demonstrates the potential of multimedia systems to professionals working in archaeology, museums and the 'heritage industry'. The Benaki Museum of Athens, the Institute of Archaeology at the University of Oxford, New Media and Mechanical Intelligence UK formed an international consortium to support the project.

Many providers and users of training technology are watching the nascent CD-I market closely, for CD-I's potential as a cost-effective and efficient training system has been recognized from the outset. A few projects have already been publicly announced:

- Renault began work on the EDIRIS technical training programme in the winter of 1989, and plan to install CD-I systems in 2000 European dealerships by the end of 1991. Four CD-I discs are being produced, with Philips International (France), with text and commentary in seven languages. The French car manufacturers were among the first to use CD-ROM for technical documentation. The move to CD-I involved 20 staff from Renault, and 40 from Philips, working for 18 months to complete the first programme.[7]
- Interactif Delta has used CD-I in training and information programmes for Carrefour, Christian Dior, Lever, La Redoute, and the French Ministry of Culture, as well as a package on Spanish history and culture.
- In the Netherlands, the legal publishers Koninklijke Vermande of Lelystad began work on CD-I packages for technical training in May 1990.
- Off-the-shelf training in Total Quality Management was undertaken by SPIN UK and Futuremedia. The first disc in the series, *The Quality Challenge*, puts users in the role of a consultant to explore ways of improving quality management in various environments. *Quality Standards* addresses the relevance, implementation and monitoring of ISO 9000/BS 5750.
- SPIN UK undertook two generic training packages with Chrysalis Interactive, in *Finance for Non-Finance Managers* and *Guide to Successful Management*.
- With the introduction of National Vocational Qualifications (NVQs) in the UK, training materials for candidates and assessors is being developed (by Futuremedia, New Media and others) on videotape, IV, CDTV and CD-I.

- With New Media, SPIN UK developed a generic induction course (primarily aimed at young people in their first job), *Welcome to Work*, which organizations can buy off the shelf, and adapt to meet their specific training needs.
- New Media and SPIN also developed management software for CD-I. The Training Management System (TMS) was the first generic product to link a CD-I player to an industry-standard PC, to allow trainers, managers and students to monitor the use of technology-based training packages.

The first initiative to develop a generic 'off-the-shelf' training package in CD-I, *Japanese for Business Travellers*, is described in the case history in Chapter 12.

EUROPEAN INITIATIVES

The Club d'Investissement Media was established in October 1987 by the Media Programme of the European Commission and the French Institut de l'Audiovisuel. Its members now include European media makers, publishers and investors from the public and private sectors. They encourage production, training and promotion to develop digital and computer techniques for graphics, high definition television (HDTV) and interactive multimedia programming.

The CD 92 project began with an initial budget of 700 000 ECUs and a call for proposals in September 1990.[8] From 1000 contacts made over the next six months, 52 proposals were received and seven projects eventually selected for funding. The topics and treatments identified in the 52 initial proposals are another small market research report in themselves.

- The majority (31) were reference or documentary packages, eight addressed language learning, five were games, four were children's programmes, two were music discs and two would develop data management software.
- Most proposed to use animation (29) or stills (15) as the main source of content (the balance being devoted mainly to audio or data).
- About half (27) were proposed by producers, a quarter (12) as co-productions between producers and publishers, and the balance by publishers alone (5), facilities houses (4) and schools or universities (4).

Nearly half the proposals came from France, and a quarter from Britain. Twelve were selected for funding in the first year.

- *Animalia*, an interactive discovery game about animals, is designed for adults and children, and will be published in CD-I and CDTV, by Coktel Vision (France), Système 4 (Switzerland) and CTO (Italy).
- *Astronomie*, from Flammarion (France) will also be published in CD-I and CDTV, to present a history of celestial objects and discovery from the perspectives of a shepherd in ancient Greece, a Renaissance scholar, an astrophysician and an astronaut.
- *Body Interact* is a three-dimensional exploration of the human body, with information on health and beauty, from Primal Pictures and MCC (Britain).
- *I was There* is a projected series of six CD-I discs for teenagers from Line TV and Roxby Press (UK) on ancient Greece, classical Rome, mediaeval Europe, the Vikings, Christopher Columbus and the Napoleonic Era.
- *The Invention Disc* is adapted from a book on inventions in various fields of applied science, from MMC (Britain) and Fixot (France).
- *Les Oiseaux d'Europe* is a CD-I encyclopedia of European bird life co-produced by Opus Species, Sittelle, Philips and CNC (France).
- *On the Farm* is the first in a projected series of programmes for pre-schoolers from Epic and Siriol Productions (UK).
- *Pocket World Interactive: Living in Ancient Rome* is also the first in a projected series which looks at daily life in formative periods of history, in a co-production between Moonlight Publishing, Edition Gallimard and CITE.
- *Retour en Prehistoire* explains prehistory to a target audience of 8- to 12-year-olds, in a French co-production between NAK, Hatier and Philips.
- *Shamrogues* is a co-production between Animedia Teo (Ireland), Telecity CD-I (Belgium) and Quadrant Communicatie (Netherlands). The shamrogues are 'imaginary stone characters possessing ancient Irish druidical powers', and the concept includes a book, a TV series, videotapes, and a variety of discs including CD-V and CD-Ready formats, as well as related merchandizing.
- *Teddy Berlitz* from Maxwell Communications and Nimbus Records (UK) provides language teaching for children, initially as part of a larger initiative by Maxwell to develop language materials for various audiences on CD-I.
- *Wolfgang Amadeus Musictionnaire* is the first in a projected series of CD-I music titles in a French co-production between Eduvision, Banques des Données Musicale, Philips and CNC.

The Club plans to renew its initiative over five years, to support some 50 new European projects in all.

The European Communities as a whole sponsor a wide range of research and development projects, primarily devoted to hardware and technology, but including some funding for innovative work in software and production techniques. Recent projects include high-quality image processing for the visual arts (in VASARI), and *Quinientos años después (500 Years After).* EC programmes including COMETT, DELTA, ESPRIT, IMPACT, MEDIA, RACE, STRIDE and STAR, among others, include projects which concentrate on, or at least peripherally involve, the use of multimedia platforms and technologies.

Independently of the EC ventures, five European companies with track records in IV and CD production formed Interactive MultiMedia Europe in April 1991. Interactif Delta, PEV and Anatome of France, Spain's MABB and the NIAM Interactive Multimedia of the Netherlands co-operated to create a European network to 'provide a secure basis for multi-national, multi-lingual and multi-cultural interactive productions.'

The CD-I market is dominated by American productions and values, a trend only reinforced by Philips' appointment of the American producer Garry Hare, Founder President of Fathom Pictures, as the first Managing Director and Chief Executive Officer of Philips Interactive Media Europe in May 1991; the succession, a year later, of Drs. Jean-pierre Isbouts, was perhaps as tactful as strategic. European titles are certainly being developed, but CD-I was launched into many foreign markets with a predominantly American software catalogue. EC initiatives and international co-productions may help to tip the balance.

BUILDING BRIDGES

For publishers, one of the most important trends in the multimedia marketing is the willingness of both software developers and hardware manufacturers to support more than one platform with suitably-tailored versions of the same programme.

Many of the first titles for CDTV and CD-I described above have been adapted from successful computer games and interactive video programmes. Other examples of cross-platform development include:

- One of the first education packages for interactive video systems in British schools, Virgin Mastertronic's *North Polar Expedition*, has been redesigned as *North Polar CD-ROM*, and was re-developed subsequently for CDTV.

- An American publishing initiative – between Longman, Davidson and Associates, and Jostens Learning Corporation – undertook to produce two electronic versions of a multimedia programme for English as a Second Language (ESL). One is based on interactive videodisc, the other on CD-ROM. Both make extensive use of licensed material from *Longman's Photo Dictionary*.

At the same time, Applied Learning – probably the world's single largest provider of training materials – regularly supply customers with integrated training packages which may involve media and methods from workbooks and classroom instruction through videotape, IV and CD-ROM. The important lesson for many users will be to apply the appropriate combination of media for the job at hand.

Notes

1 For example, see case studies and reports in *The Interactive Video Yearbook 1990* (NIVC, 1989) pp. 26–27, 60–62.
2 Mikio Higashi, Matsushita Electric Industrial Company, speaking at the First Multimedia Conference on Interactive CD, London, 18–19 June 1990; sponsored by NV Philips, Sony, PolyGram and Matsushita.
3 Claude Henri Bardot, Bordas, speaking at Microsoft's First European Conference on Multimedia and CD-ROM, Wiesbaden, 9-11 September 1991.
4 Unattributed quote reported by Jacob M. Schlesinger and Bob Hagerty, 'Philips, Nintendo May Pair Computer Games with CDs', *Wall Street Journal Europe*, 31 May 1991.
5 Eric Miller, New Media Systems, Microwave Systems Corporation, quoted by *The Videodisc Monitor*, June 1990.
6 Peter Lewis, British Golf Museum, speaking at the Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.
7 Alain Montredon, Renault Worldwide, speaking at the First Multimedia Conference on Interactive CD, London, 18–19 June 1990; sponsored by NV Philips, Sony, PolyGram and Matsushita.
8 Patrick Madelin, Club d'Investissement Media, speaking at the Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.

4

Publishing multimedia

This chapter considers factors which might influence the reception of CD-I in consumer and corporate markets. These include the experience of earlier markets for interactive video, compact discs, home computers and home video, and new trends in training, games, and information services. It includes Philips' description of the early market for CD-I, and considers marketing concepts such as push and pull, as well as pricing strategies and advice from electronic publishers.

CONSUMER MARKETS

Philips officially launched CD-I in the US on 16 October 1991, billing the CDI-910 consumer player as 'The Imagination Machine', under the slogan 'Television with a mind of its own – yours.' That summer, one enthusiast said 'We're hoping to make CD-I the VHS of interactive.'[1]

But do consumers want CD-I? Some years ago, a successful American film director was invited to comment on the results of a survey which had asked movie audiences what kinds of films they would like to see in the future. He observed that what audiences really enjoy most, is what they don't know about now and could never have imagined on their own. Interactive multimedia could be the first consumer entertainment product for at least a decade to take the audience by surprise, and delight them.

The market trends of a century and more clearly reveal cycles which could bode well for interactive multimedia products in the 1990s. Mikio Higashi of Matsushita Japan observes that 'the electronics industry historically has seen a new generation of products developed and introduced approximately every ten years.'[2] Sony's Nobuo Kanoi refines this to observe that 'the improvements and principal innovations that give

birth to new media occur roughly every 20 to 25 years … but the hardware which supports the media has a life cycle of approximately seven years,' given both technical enhancements to the products, and changes in consumers' expectations and lifestyles.[3]

Black-and-white television in the fifties, colour TV in the sixties, video in the seventies, CD players in the eighties … multimedia in the nineties? LP records in the fifties, stereo in the sixties, audio cassettes in the seventies, compact discs in the eighties … interactive CDs in the nineties? Individual products may fall by the wayside (as the format wars of other years attest) but the consumer market maintains a rhythm of its own, and the time is ripe for another new product.

It is worth remembering that, a century ago, when gramophones and wax cylinders were still upmarket home entertainment products, the introduction of horizontal discs was radical new technology. But discs soon established a universal standard and, over the course of the century, storage capacity increased, audio quality improved, and materials became thinner, stronger and cheaper. Refinements such as the changes in speed (from 78 to 45 and 33 rpm), and the introduction of stereo, required consumers to purchase new hardware and software, but demand for the product continued to grow.

The interesting footnote is that the last significant innovation in black vinyl technology – the quadrophonic sound systems of the 1970s – offered nothing that the average consumer could perceive as added value, and briefly served as a warning against hyping products which no one wanted, until the success of compact discs effaced their memory. Of course, no one wanted CD either, until the product was launched and consumers could perceive its benefits.

Interactive video

There has never been a product quite like CD-I, even in professional markets. The nearest model is probably interactive video, which offers many of the same essential features in a less attractive package, and has developed largely in corporate rather than consumer markets.

IV tends to be used intensively only in professional environments (although it is increasingly being used in schools, not only to teach specific subjects, which presages a new generation of consumers, fully conversant with interactive multimedia systems). In training and education, IV tends to operate like a computer, with users' sitting near the screen, and interacting through a keyboard and mouse, addressing captive audiences who are sometimes under strong compulsion to perform well. Yet even those who are initially intimidated by the technology can be engaged by the human

appeal of a well-made programme. The key, of course, is design: a well-made package soon has users thinking about the ideas unfolding before them, and not the system which delivers them.

The consumer market, of course, differs in many critical ways from education and training. When interactive systems are presented to the public, the hardware is usually concealed within housing that reveals only a screen and a few simple keys. Even the most comprehensively automated environments, such as Disney's EPCOT Center in Florida, take care not to call attention to the complexity of the technology that delivers the entertainment.

Of course, anyone who uses a hole-in-the-wall cash dispenser is already familiar with the basic principles – but the automated teller machine (ATM), like the training station, motivates users to persevere even if they find the system slow, awkward or confusing. When the motivation is less strong – at a tourist centre, say – unhappy users can simply walk away, probably back to another human being who can provide the necessary information in a more familiar way.

Compact discs

A successful product for the consumer market is a subtle combination of the new and the commonplace: familiarity provides reassurance, novelty excites curiosity. The attractions of a new product can be easily appreciated by comparison to something already well established.

The compact disc had this advantage in entering the consumer market. The shiny little discs were not dissimilar to audio records, nor were the player and its remote controller much different from a hi-fi system or even a VCR. The advantages of the product were manifest by comparison to records and tape. The high quality of the sound, the virtual absence of 'noise' or hiss, the greater length of uninterrupted playing time, and of course the convenient size and virtual indestructibility of the discs themselves, could clearly be appreciated.

Once the product was perceived as attractive and upmarket, there was also social cachet in owning one. (CD and Yuppie entered our vocabulary at about the same time, and the first CDs were certainly the ideal product for the upwardly mobile.) A decade later, users have come to expect lightweight portable players with CD and tape drives, and CD units for the car, to enjoy the advantages of the disc everywhere they go.

CD-I has the similar advantages, in the design of the player and the quality of the discs. It also has a much different appeal in the contents of its programmes, and the way

in which it presents information to a market as yet unfamiliar with interactive multimedia. And, of course, the CD-I system will play any compact audio disc already on the market, so the new player becomes the deluxe version of a system which is already perceived as a worthwhile and desirable product.

Home computers

Games, of course, will be the software most familiar to an established market. Yet computer games were a new concept hardly 20 years ago, unlike anything consumers had seen before. They shot to popularity with graphics and strategies which today's young players would disdain.

Games also stimulated demand for home computers at a time when few other applications had much appeal, and helped to build the hardware base which software makers need so badly. Although many packages for home users lapse well behind the standards set in professional markets, there is now an astonishing range of software specifically for the home, from financial management to family history, by way of recipes and religious studies.

There is also a growing demand for user-friendly software in vertical markets where users may run a small business with only one inexpensive computer, and amongst semi-professional organizations such as those staffed mainly by volunteers. This is a sector which CD-I could well satisfy with information and training programmes which bring new technology to environments as yet untouched by corporate video or self-paced training.

CD-I does not directly answer all the needs of these users, for it won't run a spreadsheet or manage a mailing list. However, the principles of interaction, and the idea of going to a machine for information, are familiar concepts to anyone who uses even a games console or simple PC. The significant advantages of CD-I over most home computers, in both the ease of operation and the quality of the sound and pictures from the disc, will be striking.

A brief comparison of CD-I titles for the home market, and the packages offered in, say, a catalogue like *The Macintosh Product Registry*, also suggests that there will be much to attract and astonish the current generation of home computer fans even without games. CD-I might even create a new generation of consumers, who will want to own a home computer once they understand what interactive media can do, and feel confident with interactive technology.

Home video

The appeal of CD-I to consumers familiar only with video will be different again. LaserVision, the first optical disc to enter the consumer market, appealed mainly to people who wanted to own a copy of a popular film – a fairly small sector of the market as a whole. By comparison to tape, the disc cannot record TV programmes or make home videos – and even has to be turned over halfway through the movie.

Yet where consumers have the players at home, discs are the ideal medium for video rental outlets, for they resist wear and tear much longer than videotapes. With disc, both the consumer and the retailer can expect the video to be in good condition, however often it may have been used before.

A problem emerged in the LaserVision market when video pirates realized that one disc could produce any number of (illegal) copies onto videotape, at a much high quality than tape-to-tape duplication. The video industry accordingly began to take an interest in copyright protection, and technology to enforce it.

The advantages of CD-I should be clear. CD-I is not competing directly with home video: it is as yet an inappropriate medium for a two-hour film, and it cannot record from television. But it is similar enough in appearance and operation that home video users should easily make the transition to the CD-I player and handset from the remote control unit and VCR which they (probably) already understand. If anything, CD-I will be easier to use than many programmable video recorders.

Certainly, CD-I offers a new range of programmes, many on familiar topics, in a form which should be much more appealing and satisfying to users than linear video. CD-I does not nourish couch potatoes, and there may be an advantage in that – CD-I may be perceived to support 'quality time' in a way that television alone does not. CD-I is also sufficiently different from linear video not to suffer by comparison because it does not record. Compact audio discs, and conventional records do not record, nor do books and magazines: they all offer a product which is valuable enough without that feature.

British developer William Beckett even asks, 'will interactivity put pressure on television?' Just think how often people who switch regularly between the VCR and the TV find themselves vainly pressing the rewind button when they've missed a bit of the live transmission. Will interactive multimedia have a similar effect in raising consumers' expectations of everything they see on the screen?

Where consumers may not want a disc quite enough to buy it, libraries and rental outlets could satisfy their needs. CD-I programmes are like books and videos in that people may want to own the ones they particularly enjoy or often use and borrow those

which are of passing interest. Equally, having borrowed a disc and found it worthwhile, the consumer may then be persuaded to buy a copy. In the meantime, both publishers and retailers can be assured that it is still effectively impossible to pirate a CD-I disc.

CD-I

CD-I, clearly, has features which appeal variously to a wide number of established markets – but developers still tend to see new products primarily as a variation on their familiar territory. Dr. Bernard Luskin, President of Philips Interactive Media of America (PIMA), observes that 'the consumer electronics industry sees a PC in a TV, the computer industry sees a TV in a PC'.[4]

Yet the ultimate object is not to make consumers think of CD-I as an upmarket development of home computer, nor an alternative to video, but as a unique product which combines the benefits of several other media in an entirely new way. Part of CD-I's appeal, both to publishers and consumers, will also be that it crosses many borders, not only in the features of the technology but also the contents of its programmes. It is easier to imagine a CD-I package which appeals to both professionals and amateurs, than to think of a computer database or video programme which could satisfy both.

The challenge facing developers in this or any other medium was succinctly expressed by the British publisher and journalist Tony Feldman in his book on CD-ROM: 'So the first lesson in publishing in the media of the new technologies is that their cleverness is not enough. They have to do something with information that is both different from traditional media and relevant to the needs of information users. This must add up to something for which people are prepared to pay. And the price must be enough to give you your profit margin'.[5]

Most observers have stopped saying that electronic media will displace books: the American pundit David Allen even made a home movie to illustrate that the full-computerized home is buried under paper, from the deadweight of computer magazines and mailshots in the morning post, to the shelves of manuals and documentation which accompany every piece of hardware and software. Over a decade ago, a pioneer of the interactive video market, Ron Nugent, speculated that new technologies would make people want to read *more*, by introducing them to a world of new ideas which they could profitably explore through books. (Both Compton[6] and Grolier report that the launch of their encyclopediae on CD-ROM stimulated sales of the printed version.) It may be some time before young lovers go boating on a sunny afternoon, clutching an

electronic book of sonnets with a liquid-crystal display: fine bindings may be with us for a while yet.

Successful technology tends not to be easily displaced: one observer has declared that 'new technology only replaces the old when there is a 10:1 advantage'.[7] Five centuries of commercial printing has not driven hand-lettering from the market, even if many of the talents which might once have been turned to illuminating manuscripts are now running computer graphics packages. The gifted publisher is the one who can see where new media answer the limitations of the old, and present familiar information in better and more attractive ways.

LAUNCHING CD-I

The launch of CD-I reflects lessons from the compact disc and LaserVision markets. Promotions in American shopping malls began in the summer of 1991, to introduce the product by building on its similarity to compact disc and television, rather than to computers and interactive video. A travelling exhibition in the UK, supported by a poster campaign, helped to create awareness of the product in the months leading up to its launch, in April 1992.

Retailers who promote CD-I are given a kiosk which houses the player, monitor and demonstration disc, and displays a range of software titles. It is common enough in the home entertainment market to buy hardware and software from different departments, or even from different shops. For the launch of CD-I, Philips shrewdly took the view that hardware and software must be displayed together, to stimulate interest in the product and reassure customers that the player is supported by a good range of titles. Retailers are asked to keep a choice of titles in stock, and to demonstrate any programme on request.

Philips provide both specialist sales teams and training for retailers' own staff. Bundled software will provide customers with titles which they can play as soon as they set up the machine. On the UK launch, the £599 list price included £50 worth of software of the customer's own choice and a voucher scheme which encouraged customers to claim one 'free' disc for every three or four purchased at full price. The roll-out in all national markets begins with a selection of dealers in prime urban centres, which expands to other cities and wider suburban areas. In the UK, for example, 27 dealers in central London launched the product, with 25 more joining the roll-out in the second week to create a network of some 500 distributors within the first quarter.

The 'early adopters' who are likely to buy CD-I on its release (and at its launch price) have been identified by Philips as:

- Individuals and, particularly, families, who are 'sophisticated urban consumers, interested in self-improvement, intellectually and socially aware'.[8]
- Specifically, the typical purchaser is described as a university-educated urban professional in the mid-forties, married, with two or three children, and an income of about $48 000 (roughly £28 000 – or just above the national average for two-income households).

Early adopters tend to be more interested in new products, and less sensitive to price, than the market at large, and are generally keen to be the first in their circle to acquire novelties and status symbols. In similar markets, they have also been the ones who will buy the delivery system hardware even when there is a relatively little software – as has necessarily been the case on the launch of all consumer entertainment products from gramophones to compact disc players.

Philips and others have identified several social trends which also represent market opportunities for CD-I:

- The acceptance of self-paced study and distance learning which Philips' President and Chairman, Jan Timmer, describes as 'the growing consumer quest for self-enhancement'.[9]
- The popularity of CD audio systems, for which consumers readily bought both hardware and software (and, sometimes, associated products such as new speakers to complement CD's high-quality sound).
- The familiarity of computer and video screens in the office, school and home (and, indeed, of simple interactive systems such as hole-in-the-wall cash dispensers), as well as increasing familiarity with input devices such as the remote control keypad, joystick, mouse and computer keyboard.
- The trend toward digital technology in virtually all sectors of the communications industry, from broadcast television to electronic publishing.

Already, some studies have analysed hardware and software sales in established multimedia markets, and made informed predictions for future performance. Publications such as the invaluable *Multimedia and Videodisc Monitor* in the US, and *Screendigest* in the UK, note the latest reports and summarize their key findings.

Only time will tell if these predictions are accurate, but information of this kind often helps to build the business case, if only to demonstrate that these new markets support

research and analysis at this level. New Media's Manager Director, Dick Fletcher, compares current speculation on the future of multimedia to 'asking Caxton to forecast the Webb offset machine.'

Market research and commentary, however prestigious the source, should always be taken with a grain of salt: when the *Wall Street Journal* declared that 'CDTV Also Could Be a Flash in the Pan', one critical aspect of that report compared 'Average 1990 factory sale price' of CDTV at $1000, VCRs at $241 and CD players at $170, without noting any difference between the launch price of CD-I and mass-volume price of products which had been in the market for a decade or more.[10] VCRs, CD players and home computers were relatively much more expensive on launch than they are today, and the launch prices of CDTV and CD-I are similar to that of CD audio on its release.

Multimedia systems are being launched with a much higher level of functionality than the first VCRs or home computers, but they face a much more discriminating and computer-literate market than did those first high tech products. Philips' Gaston Bastiaens, speaking at Microsoft's Seventh Annual International Conference and Exposition on Multimedia and CD-ROM in San Francisco in March 1992 – just five months after the American launch of CD-I – reported that the new format was in fact selling a little better than audio CD had done during the same period after its launch.

PUSH YOU, PULL ME

The shape of this new market will also be profoundly influenced by 'early adopters' within the publishing and production industries – the companies which elect to support interactive multimedia platforms with off-the-shelf products and bespoke services for corporate clients.

In Britain, the first companies to make IV tended to come from the corporate video and training sector, and the market concentrated there accordingly. In the US and Germany, many organizations with a background in sales and marketing saw the potential of the new technology, and developed applications in those sectors. Italy has encouraged the use of IV and multimedia systems in state-funded projects for public information, and Italian publishers were among the first to exploit CD-ROM commercially – not the least, because the Italian telecommunications service fell behind those of other European countries in the support of on-line data services, while the sheer volume of Italian tax laws in particular demanded a radical solution from information-providers which conventional publishing could not provide.

The market for new multimedia platforms may well develop similarly, subject as much to historical as technological factors. If the success of electronic publishing in Italy is not an unqualified endorsement of technology, so much the better – for the Italian market led the way in applying technological solutions to larger communication problems. The smart money is likelier to invest in products which meet the needs of a definable market – which, in marketing terms, respond to the market's 'pull' – more confidently than those which have to create their own demand (marketing's 'push').

For publishers, the stakes vary considerably between what are now separate markets. Books, of course, do not require hardware, but all electronic publishing ultimately depends on the 'installed base' of hardware on which the software can be played. When Pioneer re-launched LaserDisc with $500 players, it was with a distinct view to building the hardware base to stimulate software development, and breaking the cycle which retarded the development of interactive video.

This is a cycle in itself, of course, and the ultimate penalty is rapid penetration followed by market saturation. When virtually everyone in the target market has one, there's nowhere else to go. Television has effectively reached this plateau in the industrialized world, and is advancing relentlessly through eastern Europe and the developing world. One of the real attractions of radically new television technology to the hardware trade is the prospect of a new international market for production and broadcast equipment and TV sets. (Equally, in our enthusiasm for compact discs, the consumers of the affluent world tend to forget that vinyl records still support enormous markets in countries where personal stereos and CDs are imported goods at the upper reaches of the luxury trade.)

The great uncertainty of course lies with the consumers themselves. There are certainly many video specialists who deplore the emergence of VHS as the *de facto* standard, when other tape formats of the seventies offered better technical quality – but VHS proved the optimum product for the consumer market, for a variety of factors of which resolution is only one. Where users can employ technology creatively, they often find applications which the industry did not foresee. Videotape was meant for consumers to buy films and make home movies, but users themselves quickly discovered the greater appeal of 'time-shifting' broadcast television, and renting films overnight. The demand for longer tapes and 'extended' recording facilities was driven primarily by consumers' enthusiasm for long sports events such as football games.

One pragmatic view of the potential market is demonstrated by Dr. Bernard Luskin, whose presentation aids include a satellite photo of the US by night, a silhouette spangled with light. 'The market,' he says, 'is where the plugs are'.[11]

THE PRICE IS RIGHT

CD-I and CDTV discs may be competitively priced by comparison to video games and professional computer software, but both are pitched primarily at consumers outside these markets, to whom their economics mean nothing. By comparison to audio CDs, videotapes or books, interactive multimedia software lies at the upper end of the market. A home health guide which costs as much as a medical textbook must offer much more than any similar product, for there are many inexpensive paperbacks in the competitive market for health care and self-help.

Publishers in consumer markets face direct competition from products in radically different media. CD-I discs are likely to be sold in environments as diverse as music shops, bookshops, toy shops and department stores, where consumers are often as much concerned with the unit price as with perceived value for money.

Many publishers found many new outlets in the market-driven climate of the last decade. Video rental outlets which once controlled a niche market are suffering now that corner shops, supermarkets, late night grocers, service stations – as well as bookshops, music shops, department stores and libraries – all offer videotapes and even computer software for sale or hire.

Equally, the market for home computers has already accustomed both retailers and their customers to the sight of computers sitting alongside television, hi-fi and video systems in specialist shops and department stores. The market for games in particular has put computer software on the shelves of music shops and book stores. Multimedia products for the consumer market are already following suit, and interactive compact discs will join paperback books, videotapes and computer games in outlets of all kinds.

CD-I was launched with recommended retail prices of $19.95 to $59.95 per disc in the US, and £14.95 to £39.95 in the UK. Jerry Lundquist of Interlight Productions, who developed a series of *Children's Bible Stories*, notes that their first title, *Noah's Ark*, will compete with a 30-minute animated videotape from Hanna-Barbera, and a Nintendo game of 'Bible adventures', which sell for $12.95 and $39.95 respectively.[12] In most retail establishments, all this software must compete on the same terms for expensive floorspace, and new products have to win their share quickly and stay competitive to hold their ground.

Many other CD-I titles will compete directly with books, videotapes, audio cassettes and CDs – not to mention the many other claims on pocket money or disposable income – in a market very unlike those for interactive video or professional databases, where many electronic publishers learned their trade. Whatever the quality

of the software itself, consumer products will have to be packaged and promoted competitively to gain a share of such diverse markets.

The discrepancy between list prices in the US and the UK also suggests that CD-I, with its universal technical standards, is vulnerable to 'grey imports' – products purchased where prices are low, and resold where they are high. Many computer and games manufacturers tailor hardware and software so that illegal imports will prove technically incompatible, but CD-I specifically promises that any disc will run on any player. There are some grounds for the difference between American and British prices (including fluctuating exchange rates and VAT, a hefty 17.5 per cent internal sales tax); however, with CD-I as with audio discs and tapes, canny consumers may try to shop abroad – on holiday or through mail order services – whenever they can.

The British consultant Jim Mackonochie particularly advises newcomers to respect the established values of publishing in the vertical and mass markets:[13]

- Publishers may address vertical markets with their own sales force, through distributors, or by bundling software with hardware products. Software is usually sold at 30 per cent to 40 per cent below list price to distributors in vertical markets.
- Publishers who address consumer markets directly, unless they also control their own retail outlets, generally employ professional distributors, or bear the cost of advertising and promotion as well as sales. Publishers' margins are generally lower in mass markets, but vary greatly from one country to another.
- New markets may be breached by establishing a branch office and sales force, or through a local distributor. Products licensed by other companies are often re-packaged, with scant reference to the original producer. Publishers who wish to project their own image may prefer to affiliate with a company which distributes a range of individual labels.
- The 'felt fair' price varies greatly between countries depending, for example, on economic factors such as disposable income. At any one time, currency exchange rates, shipping costs, duty and sales taxes may also add appreciably to the retail price in foreign markets, or affect the publisher's net profit.
- Producing appropriate versions of software and packaging for every national market enhances the local appeal of the product, and discourages 'grey marketing' among distributors who buy in cheap markets and re-import to expensive ones, where they can make a profit even after paying tax and duties.

One observer of the Italian CD-ROM market calculated that a software product which cost $500 000 to produce – a high but not unheard-of figure for the first generation of

CD-I titles – typically needs sales in the region of 800 000 copies to be financially viable.[14] (In July-August 1991, *The Multimedia and Videodisc Monitor* reported that *Treasures of the Smithsonian* cost $750 000 to produce, at a time when average titles cost around $300 000 – a figure which should come down as experience grows and more production tools become available.)

Clearly, there are surprises here for developers whose experience lies elsewhere. Distributors may take a share of the profits, but they may also guarantee a better return in the long run, and leave programme-makers free to concentrate on what they do best.

SOME PUBLISHERS' VIEWS

Publishers of electronic and conventional media contributed much to the discussion of potential markets for multimedia products in the years when these platforms were available to developers but not to consumers. At Microsoft's 1990 conference, the American publisher Fred Durr set CD developers four tasks:[15]

- Identify the target market.
- Size up the competition.
- Establish a price.
- Find distributors.

(In the spring of 1991, Microsoft themselves purchased a 26 per cent 'strategic share' in Dorling Kindersley, a London-based publisher and packager of illustrated reference books of the type ripe for conversion to multimedia. Publishers with a strong base in print and established distribution networks, such as Rizzoli Corriere della Sera – which already own the rights to much information which can easily be adapted to multimedia platforms – were among the most important 'early adopters' on the supply side.)

At the same Microsoft conference, Greg Smith of Meridian Data identified the first step in any project as 'determining whether there is a market', and noted that his company's small marketing department 'just responds to users' screams'. Yet this perhaps confirms the view expressed in the British Library's research paper *Information UK 2000*, that: 'The slowness of publishers to react to change may allow new players, including smaller organizations which are able through IT to address niche markets, to take the commercial initiative'.

At CD-ROM Europe '91, Gordon Jones of The Times Network Systems (TTNS) identified important tasks for information providers in all markets:[16]

- Increase awareness of the technology and its benefits in the target market.
- Help to increase the installed base of hardware.
- Provide a complete starter pack to make new users productive quickly.

Several issues which he related to education, *mutatis mutandis*, apply in other fields:

- Making life easier for users by recognizing the many other demands on their time, and providing products with short learning curves and some 'instant' results or applications.
- Providing 'excellent value for money' with products which stimulate further ideas and wider use – and are tailored for each specific market, rather than 'dumped' from a primary market to a secondary one without modification.
- Obtaining the endorsement of a relevant authority – whether a government department, the head office of a company, or a professional organization.

Building the market, he observed, also depends on conducting sound evaluations of real work in the field, and publishing these results to validate the initiative, share experience and make recommendations.

Ian Brackenbury, of IBM UK, observes that separate factors inhibit the growth of young markets from within and without.[17] Hardware and software providers are typically hindered by a lack of uniform technical standards and authoring tools, high investment and production costs, and little evidence of sustained performance or proven applications. Potential customers, on the other hand, do not always immediately see the need for new systems, and may have substantial investments in other hardware and systems to protect. As these issues are addressed, markets grow accordingly.

Addressing the market for corporate training, David Roux of Lotus Development Corporation warns that large companies rarely take global initiatives, but prefer to buy direct, department by department.[18] They also expect worldwide support and on-site training from suppliers. He advised electronic publishers to:

- Act now: waiting is the greatest risk.
- Build products, not prototypes.
- Employ dedicated marketing methods.
- Assume that sales will be expensive.
- Never underestimate the cost of support.

The first phase of growth in these new markets must be led by developers, of both hardware and software, who can expect to work hard for their rewards. But if the

interactive multimedia follows the model of its predecessors, the next phase will be led by 'customer's screams' for the software and features they desire, rather than the whistles and bells of technological innovation.

KEY QUESTIONS

All published work short of the vanity press has at some point to win the support of a commercial backer. For interactive multimedia, being both less familiar and more expensive than many traditional formats, it will be essential to build a strong business case and present it coherently. 'Meeting objections' is a typical stage in any selling process, which multimedia developers particularly must be able to face with strong arguments for the value of their proposals.

The case for interactive multimedia is clear enough to publishers who already deal in software or who want to enter this field. However, the actual choice of titles and projects is critical if CD-I is to establish a solid base of 'early adopters'. Indeed, there is a good argument for concentrating on key markets to develop a choice of complementary titles (consider Philips' package for golf and sports clubs, described in Chapter 3, Multimedia Titles). A title does not have to be unique, and there is no inherent value in novelty alone, but the project must suit the formats for which it is intended, and be achievable within the constraints of those platforms.

The sound business case will present irresistible arguments for publishing on interactive multimedia platforms rather than traditional formats.

- Why does this title need to be produced as an interactive multimedia programme? Why multimedia? Why interactive?
- Who would want to buy it? Would they readily pay the asking price?
- What special value does this programme offer its users? What would the same money buy them in another medium?
- How many hours of use or entertainment can a typical user expect from this one package? How many people in a household are likely to use it?
- How long is this package likely to stay competitive? How soon will its subject matter, contents or style look dated? Can it economically be updated?
- What similar titles exist in other media? Are they successful? Why?

The British developer William Beckett began to produce an interactive programme about Sir Ranulph Fiennes' 1979/82 Transglobe Expedition when interactive video

was young, and has followed the market for some years with versions of the package on IV, CD-ROM and CDTV.[19] From his considerable experience in presenting new media to conventional publishers, he recommends that companies which are looking for partners and support:

- Develop a demonstration version of their package as 'proof of concept'.
- Produce a videotape which introduces the programme and simulates interactivity (at least until the installed base of appropriate hardware is large enough to guarantee that possible investors can play a real demonstration disc).
- Quote research papers which demonstrate the effectiveness of interactivity, and the commercial potential of multimedia.

Beckett notes particularly that 'traditional publishers do not understand group interaction,' and strongly advises developers to take on the educative role as long as it is needed to familiarize new commercial partners with the potential of interactive multimedia. Having developed the original *North Polar Expedition* for the British schools' market, he is one of the many who insist that 'you cannot penetrate the school unless you penetrate the home.'

The Swedish publisher Kari Marklund of Bra Böcker – who based the launch of CD-I software to Scandinavian markets on the model of a network of successful book clubs and mail order services – recommends that a well-rounded catalogue include 'something for him, something for her, and something for the family'. (He also noted that the CD-I launch catalogue was rather short on 'titles for her'.[20])

TRENDS AND OPPORTUNITIES

The applications described in the previous chapter suggest some of the established markets which interactive multimedia systems could address, and some of the innovations which may lead to large new markets.

Licensing the famous

CD-I is already providing a new platform for popular characters and games from Sesame Street, Hanna-Barbera, Hasbro, Nintendo and Parker Brothers, among others. Licensing well-known characters or stories is of course an attractive option with benefits for both sides, for popular subjects provide the developer with a creative model

and a waiting market, and new multimedia products can revive flagging markets when conventional merchandizing has reached saturation point.

A few hours of children's television, or a visit to a large toyshop, reveals how many and various are the figures already licensed for exploitation in cartoons or the enormous range of goods which can bear logos and images. Many of these are still ripe for development as multimedia titles, where existing licences do not address these new platforms, but the rights to popular icons may be very expensive.

Equally, although spin-offs can certainly make money, if the original was popular and the new product offers genuine added-value, designers must always work to satisfy preconceptions shaped by work in another medium, and find new ways to add value to familiar products. Working with well known characters and stories sets challenges against advantages almost equally.

Just-in-time training

'Just-in-time training' became a buzzphrase in corporate markets, as employers realized how much training is provided on short notice, to avert the worst consequences of not training, rather than within a professional development plan.

Corporate video offered one medium which trainees could use at work or at home, but linear programmes are clearly not the medium to engage and challenge the home user. Cross-platform development in, for example CD-ROM XA and CD-I, offers a viable alternative, with interactive programming which users can play on a CD-ROM workstation in the office or site, and take home to play on the CD-I system in the living room or study.

Parlour games

Novalogic's John Garcia asks, 'What does the home market really want? Entertainment'.[21] He argues that games are the mainstay of the home computer market, and the producers of multimedia titles must follow suit if they are to attract the real audience for interactive CD. (One European publisher describes the software market as 50 per cent games, 40 per cent educational, and 10 per cent reference works.[22])

Garcia also identifies a commercial argument which will attract games-makers to compact disc. The material cost of a single ROM cartridge for a home computer is typically \$15 to \$25, without the cost of developing and marketing the software itself. To publish 100 000 copies of a computer game represents an outlay of perhaps \$2m

on cartridges alone. Compact discs might reduce that to $1 per disc. This is a persuasive argument for software publishers of all kinds, and a distant early warning for CD-I developers of competition to come.

Video games are largely designed for single players, and the games console or computer is as likely to be in a teenager's bedroom as a family room. However, many developers are keen to argue that the multimedia games are designed for families. At the Intertainment '89 conference in New York, Robert Gehorsam of Prodigy Services/ Entertainment advised that interactive systems should be seen as entertainment for use by adults in the living room. He argued that successful games should encourage social interaction between players, and looked to collaborative rather than purely competitive models. He also suggested, perhaps wishfully, that good narrative games might encourage children to read more.[23]

The positive arguments for computer games suggest that they help to develop hand-eye co-ordination and problem-solving skills, and illustrate how patience, ingenuity, strategy and courage may variously be appropriate in different circumstances. Games which encourage teamwork and the exchange of ideas are good models for social behaviour in many other contexts. (This is not to say that many of the first products in the CD catalogues are not simply shoot-'em-ups with heightened visual and audio effects, or that the social value of games like CDTV's *Psycho Killer* are immediately apparent to all observers.)

Many board games simply provide attractive accessories for traditional games which can be played with pencil and paper alone. *Battleship*, with computer graphics, archival footage of naval warfare, and vivid sound effects, does as much in CD-I. Other boxed games offer stimuli for creative activities such as charades or word games, which traditionally rely on players' own resources. If multimedia products are to foster social interaction, it may be in designing games which do not rely entirely on the screen, but provide ideas and score-keeping facilities, and encourage players to interact with each other.

The collective view expressed at the recent Intertainment conferences favours medium- to long-term strategies. Marketing and corporate structure may be important as design and production skills in attracting mass audiences who have not been addressed collectively before. The delicate balance between innovation and profit may lie in new relationships between large companies with the infrastructure, capital and experience to support new ventures, and the smaller companies or individuals with the creative skills to initiate new ideas.

Coin-op games

The ACE Genius, a coin-op trivia game developed on CD with DVI technology, was described briefly in the previous chapter. It is the first of what could be a lucrative application of multimedia technology to a market hitherto held back by its delivery systems.

In the April 1991 issue of *IMI Newsletter*, Tony Feldman reported that there are about 35 000 coin-op games in British pubs, and at least another 10 000 in clubs, bingo halls, games arcades, motorway rest stops and similar environments. About £60m worth of hardware is sold each year, and some £170m is collected in 'stakes' from players (most of whom are young men, from 18 to 24).

In Britain, the whole operation is closely regulated by the Gaming Board, and the maximum amounts which can be staked and won are fixed by law (in 1991, at 20p per stake, and £12 per jackpot) – not the least, to discourage the professional gamblers and organized syndicates which larger prizes attract. To avoid the regulations imposed on gambling, these games require some demonstration of knowledge or skill from the player which defies mere statistical probability. Amusement with Prizes (AWP) or Skill with Prizes (SWP) therefore require gaming strategies and resources which provide a challenge to casual players, but defy dedicated gamesters who will play many rounds until they learn how to beat the system.

Interactive compact disc obviously provides a platform which combines large databases with attractive and interesting multimedia presentations in a single, small, cheap, robust storage medium and delivery system. The addition of still and moving video, and audio clips, to the familiar computer graphics and sound effects, not only enhances the appeal of AWP and SWP games, but also provides a whole new range of formats and questions. The real challenge in this market will be to find a rich lode of source material to support the tens of thousands of questions which a popular game demands.

It is sobering to remember that the phenomenal success of *Dragon's Lair* in American games arcades caused a gold rush in the videodisc market in the summer of 1983 – which, like others before it, made money for the first few adventurers, and left most of the late arrivals high and dry. The problem then was that the craze for videodisc-based games with high-quality animation or true video was something of a passing fad, and those which did not make money quickly were prohibitively expensive to produce by comparison to conventional games.

With this new generation of coin-op games, it is likely that much less money will be spent on achieving cinematic production values. Developers will concentrate on acquiring the rights to large quantities of information for questions, and designers on

templates and production routines to support the demand for new products which this market, with any degree of success, could generate.

Database services and subscriptions

Many developers think exclusively of creative projects which lead to a single product. However, there is a growing market for work which simply re-packages public information in a way which is convenient and interesting to users with particular needs or interests. CD-ROM titles such as Philips' *European Business Guide* are effectively services, which collate and publish data from a variety of sources.

There is little creative input here once the package is designed, for consistency in style and structure is an advantage for regular users as well as the production team. The business of maintaining such a database demands both rigid conformity to routine and meticulous attention to detail. The winning formula for a successful database can be as elusive as that for a successful magazine; in both markets, glossy consumer products represent a small share of an industry largely devoted to professional publishing.

Such databases rely on the acquisition and processing of public information. Much research, planning and design must go into the structure of the product, and marketing will probably depend on a strong launch, but both production and promotion typically then settle into a routine. It is important to establish reliable data sources and a standard contract with these providers to ensure that updates are supplied routinely. Equally, it is important to support subscribers with prompt and efficient delivery, billing and renewal services. (Depending on the complexity of the product, it may add value to provide a telephone helpline and technical support, too.) It is vital that the publication process is streamlined to reduce both the tedium and the expense of redundant effort, and to ensure that updates are always released on schedule.

Much of this may be anathema to the Creative Director, but the Financial Director will appreciate the appeal of a nice little earner with a low emotional profile. Real success in multimedia publishing may be the reward of those who think creatively to find new opportunities in established markets.

PUBLISHING IN-HOUSE

If interactive video has one lesson to offer the multimedia markets of the future, it is that no technology provides a standalone solution to human problems. Interactive

systems cannot sell products or train staff any more than linear video or computer-based training can. However, as part of a coherent training programme, with support from line management in the workplace, multimedia systems can provide self-paced study for groups and individuals, and attractive presentations which trained staff can use to present products and services comprehensively and persuasively.

Without support, an interactive programme is about as effective as a manual on the shelf or endless loop of a promotional video. Those with motivation and skills will take the initiative and learn. Most of the rest will stumble for lack of guidance and support. Successful applications provide not only style and content, but context and support – self-paced study and group work, technology-based training and classroom instruction, simulations and on-the-job experience.

Speaking at Microsoft's 1990 CD-ROM Conference, Wayne Reed, a project manager with Coca-Cola, offered pertinent advice for all developers:

- Secure the support of senior management.
- Know what your basic package will include.
- Educate yourself to make informed buying decisions.
- 'Find vendors who will be around for a while.'
- Go to vendors' seminars to learn more about them, the market and the competition.
- Share your project plans with vendors.
- 'Learn before you burn' – observe, analyse and benefit from the experience of others.
- 'Don't spend money before it's necessary.'
- 'Get it in writing.'

COPYRIGHT

To re-design work produced in another medium, or to use archival material in a new production, it is important to determine that the content is still sound, and the quality of the material is equal to the new platform. If this seems likely, the critical issues which must next be addressed are neither creative nor technical, but ethical and legal.

Assets

Material originated by any other party is usually subject to copyright. Even where music or publications are out of copyright, the interpretation of these by living artists

may impose creative rights of another kind. Printed work in books and magazines may be owned by the author, publisher or even an estate or trust.

Copyright governs the reproduction of illustrations from a magazine or encyclopedia, and from postcards or slides from an art gallery. Pop songs, radio broadcasts, and everything on television is subject to copyright. Because digital multimedia systems *can* capture all this information and re-process in new ways, does not mean that the multimedia developer *may* do so with impunity.

Neither can publishers or programme-makers necessarily claim material which they developed in another medium. Having produced the book or video is not a *carte blanche* to create a CD-I version unless the rights for this form of reproduction have been agreed with all those who provided the original material.

Equally, the performing rights to the work of actors, musicians and other artistes must clearly state how recorded material will be used subsequently. As often as TV programmes are broadcast, residuals are due to the people whose work they represent. Recorded or broadcast material cannot be re-used without permission from its creators. Even characters, concepts, words and images can be registered or trademarked, and only licensed from their rights-holders.

Copyright was one of the most painful lessons learned during Britain's experimental Interactive Video in Schools project (IVIS) in the mid-eighties. Much of the material released to the developers of the project's eight interactive videodiscs was given generously to a pilot project in education – but withheld absolutely when it was proposed that the same discs should be published commercially. A project which changes course in mid-stream may forfeit both its earlier contractual relationships, and the goodwill with which they were made.

Intellectual property

Copyright obviously covers source material such as still and moving pictures, music, and extracts or quotes from other media. However, it also covers a variety of less tangible material, including statistical data, market research and intellectual property, all of which may be as closely guarded as any audio-visual source.

Sports, which offer so many opportunities for games and special interest programmes, are particularly challenging for this very reason: all the broadcast quality footage, newspaper and magazine photographs, even the collection and analysis of statistics, represents protected professional work. A simple idea for a computer game on baseball became an 18-month exercise in negotiating skills, and still came to nothing

after the developers calculated that 43 per cent of the gross wholesale price of the finished game would go to the copyright holders whose databases and picture libraries made up the tangible portion of the programme. The veteran of that experience, Garry Hare of Fathom Pictures, says, 'We need to take a guerilla approach to rights acquisition. Find someone with rights ownership, and don't make a deal – build a relationship'.[24] (He went on to create *Palm Springs Open* with original video footage.)

Similarly, the American National Museum of Racing faced many challenges in assembling footage for its interactive displays. Copyright fees meant that much of the material in video libraries and television archives was too expensive, and the research to identify and secure material from other sources (such as breeders, owners and race tracks) demanded time, effort and travel with no guarantee of success.[25] On the other hand, for archival footage of warships in action, Capitol Disc Interactive went to the US National Archive, and acquired some hundred short clips, free of copyright, for their CD-I version of *Battleship*.

Setting a price

The bright idea itself, and all the work that goes into developing, producing, marketing and distributing a new product, may be the developer's only contribution to a package which depends for its content entirely on other people's work. Each side has to recognize the contribution of the other, to reach licensing agreements which are both ethical and profitable. Patrick Gibbins, a British multimedia publisher, described the dilemma succinctly: 'There is a clear conflict of interest between the publisher, who is trying to reduce risk, and the intellectual property holder, who wants compensation'.[26] He suggested the following guidelines for publishing on CD-ROM:

- Text: 20 per cent to 30 per cent of net, with no advance.
- Pictures: $75-$100 per image.
- Commissioned music: $1000 per minute.
- Published/recorded music: 6 per cent per track.

If anything, some of these estimates are low: National Geographic photographer Nathan Benn has observed that a stock shot may be sold to a textbook for $150 – with a 50:50 split between the photo agency and the photographer – but a syndicated photo story could fetch $100 000 internationally. He also noted that administrative costs and other small fees contribute substantially to the final cost of images in the lower end of the market, quoting a typical price of $175 per image at an agency which specialized

in illustrations textbooks and reference material. He reports that another developer paid a rock-bottom $35 per image in administrative fees for archival material which was actually out of copyright.[27]

Benn argues that information-providers such as photographers need to organize national copyright collectives on the model established in the music industry to administer licensing, and the collection and distribution of fees. Video and photo agencies and libraries tend to be independent commercial concerns, with no institutional price structure; however, they provide both the work of famous photographers and photo-journalists, as well as 'generic' shots for print and audio-visual recordings. The music industry similarly has libraries of material specifically prepared for audio-visual productions, as well as special recordings of music out of copyright which will be cheaper than performances of the same work by well-known artists or orchestras.

Whatever the source, it is essential to define at the outset exactly how and where licensed material will be used. There are often different arrangements for commercial, professional and educational markets. One song may be licensed variously for publication as sheet music, translation into another language, recording on audio disc or tape, live performance or use in a jukebox or karaoke machine, broadcast on radio or television (whether network, cable, satellite or closed-circuit services), synchronization as a soundtrack for film or video, or upgrading from an original analogue recording to a digitally-enhanced version. Virtually all these conditions could be involved in the treatment of audio-visual material within an interactive multimedia project.

Moreover, it is often possible to license a single verse or quotation, rather than an entire work. Jukeboxes and karaoke machines can record the number of times any one item is played, to calculate royalties, but for interactive systems, rights are usually secured by a one-off payment, or royalties based on unit sales. This may involve both a payment up-front to secure the rights, and royalties subsequently, perhaps on a sliding scale according to the number of units sold. A single payment may be cheaper in the long-run if a programme sells well, but royalties, which only have to paid once the package is making money, are easier on the cashflow.

Rights for recorded music particularly must be cleared in every country where the product is sold. International distribution can affect calculations considerably, and to change the terms of the distribution agreement after signing may not only be expensive, but legally prohibitive.

A responsible approach to copyright demands research and paperwork, even to establish that material is within the public domain. This could be the job for an

experienced administrative or production assistant where the number of items is small, their sources are easily identified, and their proposed use can be clearly defined. In projects which are largely or solely based on material originated by others, this can be a full-time job for someone with professional training.

Organizations unaccustomed to dealing with copyright should take legal advice and use professional services in handling anything which is or could be protected – and should explain the intricacies of interactive multimedia as often as necessary, to ensure that everyone understands how material may be employed and interpreted.

A question of interpretation

Digital image capture and manipulation presents editors and artists with a new order of creative tools, and a new twist to an old dilemma. All media support special effects, collages and downright forgeries to various degrees: it is the ease and quality of digital editing which makes these liberties so tempting. Already, picture magazines in Britain and America have been caught with strangely unfamiliar beauty shots of famous places, which had been digitally doctored to create a more pleasing effect – even when this meant moving the pyramids or replacing a ruin with a bank of spring flowers. In explaining his enthusiasm for digital video to the BBC's *Late Show*, the British artist David Hockney observed that 'the veracity of the photograph is about to end'.[28] That programme's editors described his work as 'photo-realism without the inconvenience of reality' – an exciting prospect for the fine arts, and a difficult one for journalism.

Copyright and licensing agreements are only too easily infringed, and it is impossible to say where an aggrieved artist or rights-holder may take exception to unauthorized activity. The pop music trade, for example, has seen damages awarded to artists who objected to the use of 'soundalikes' whose performances, nearly indistinguishable from their own, capitalized on their work without permission or remuneration. As well as fines, this might provoke an injunction which could put an end to the entire project, or seriously damage its producers' cashflow, production schedule, distribution network and professional reputation.

Equally, the right to interpret, edit or adapt someone else's work is a minefield even for specialists in copyright law. The resemblance between new work and protected sources is often a question of subjective judgement, even in lawsuits. Digital multimedia systems offer designers opportunities unparalleled in the history of publishing to re-process, distort, disguise and embellish other people's work in a way which may be creatively exciting, but ethically dubious.

Protecting your own work

The other side of the copyright question is, of course, protecting your own work. So far, multimedia programmes have been too complex to copy directly. The use of optical discs protected developers and publishers when these formats were difficult to produce, and impossible to copy outside a professional production facility. Yet there has already been dispute over the right to replicate interactive videodiscs[29] and a new range of recordable discs and disc-to-disc transfer facilities may yet make interactive multimedia vulnerable to piracy.

One technological solution lies in encryption codes, which either prohibit copying or at least shut the barn door by branding the copy so that its illegitimacy might be proven subsequently. In desktop publishing, for example, one disk may store many text fonts – small units of data which are nonetheless valuable; users buy the whole disk, and pay for discrete codes to access each font individually. These are usually different for every registered user, and every file on the disk, to prevent users from swapping codes between themselves. This of course requires extra software and administration but the system, once in place, supports a wide range of similar services, including games. CD-I can support up to 32 applications on a single disc, and control access to each one through a discrete code.

Some legal protection now lies in copyright law which, in Britain for example, treats a computer program as a literary work in its own right as soon as it is recorded onto a floppy or hard disk, CD-ROM or other storage medium. Copyright usually resides with the author except where work is clearly undertaken for an employer: with the widespread use of freelancers and consultants in the multimedia industry, it is also important to define the ownership of intellectual and material property in a specific contract of employment for every person in every project.

In the longer term, it is important to anticipate technological innovations which may affect both existing copyright arrangements, and the future of the interactive multimedia programmes into which they are incorporated. Developers need to think seriously about the shelf-life of their own work, and whether they need exclusive or perpetual rights to ensure that new versions of successful programmes can be adapted to new platforms and markets in years to come.

Notes

1 Kevin Gillen, Gillen Interactive Group, speaking at the Society for Applied Learning, 21–23 August 1991.

2 Mikio Higashi, Matsushita Electric, speaking at the Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.
3 Nobuo Kanoi, Sony Corporation, speaking at the Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.
4 Dr. Bernard Luskin, PIMA, speaking at the Second Multimedia Conference on Interactive CD, London 29–30 May 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.
5 Tony Feldman, *CD-ROM*, Blueprint, London, 1987.
6 Stanley Frank, Encyclopedia Britannica, speaking at Microsoft's Sixth International Conference and Exposition on Multimedia and CD-ROM, San José, 18-20 March 1991.
7 John Latta, Fourth Wave Inc., speaking at the Third Annual Digital Multimedia Conference, Boston, 24-26 July 1991, sponsored by BIS Strategic Decisions.
8 Edward Arroyo, Philips Interactive Media of America (PIMA), speaking at the First Multimedia Conference on Interactive CD, London 18–19 June 1990; sponsored by NV Philips, Sony, PolyGram and Matsushita.
9 Jan Timmer, Philips Industries, speaking at the Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.
10 Patrick M. Reilly, 'It's a Computer! It's a TV! And It's a Stereo! But CD TV (*sic*) Also Could Be a Flash in the Pan', *Wall Street Journal Europe*, 3 June 1991.
11 Dr. Bernard Luskin, PIMA, speaking at CD-ROM Europe '91, London, 21–23 May 1991.
12 Jerry Lundquist, Interlight Productions, speaking at Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.
13 Jim Mackonochie, Consultant, speaking at CD-ROM Europe '91, London, 21–23 May 1991.
14 Guido Bucciotti, Instituto Geografico de Agostini, speaking at Microsoft's First European Conference on Multimedia and CD-ROM, Wiesbaden, 9-11 September 1991.
15 Fred Durr, National Information Services Corporation, speaking at Microsoft's Fifth International CD-ROM Conference and Exposition, San Francisco, 27 February–1 March 1990.
16 Gordon Jones, TTNS, describing an initiative between TTNS and Toshiba to put CD-ROM drives in British schools, at CD-ROM Europe '91, London, 21–23 May 1991.
17 Ian Brackenbury, IBM UK Laboratories, speaking at CD-ROM Europe '91, London, 21–23 May 1991.
18 David Roux, Lotus Development Corporation, speaking at Microsoft's Third International Conference on CD-ROM, Seattle, Washington, 1–3 March 1988.
19 Hon. William Beckett, Developer, speaking at CD-ROM Europe '91, London, 21–23 May 1991.
20 Kari Marklund, Bra Böcker Publishing Group, speaking at the Third Multimedia Conference on Interactive CD, London, 28–29 April 1992; sponsored by Philips, Sony, Matsushita, Bra Böcker and Infrogrames.
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23 Robert Gehorsam, Prodigy Services/Entertainment, speaking at Intertainment '89, New York, 30 October–1 November 1989.
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27 Nathan Benn, Editorial Photography in Multimedia, *The Videodisc Monitor*, September 1990.
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29 'Rodesch Sues Over Illegal Replication', *The Videodisc Monitor*, October 1989.

5

Designing for interactivity

This chapter complements Chapter 9, Stages in Production, with a fuller description of the instructional and creative phases common to all interactive multimedia projects. It considers 'how much' information can be put on a compact disc, and how creative decisions and conventions affect the design at least as much as technical constraints. It describes the work of instructional design and the importance of research to identify the target audience, their needs, and the factors which may influence their reception of the programme. This chapter also considers principles of good design for consumer and professional applications, including the importance of navigation and the use of metaphors, and offers some guidelines for efficient and effective interactive design.

THE FRUIT BOWL

The first thing many people ask about CD-I is 'What can you put on a compact disc?' What can you put in a fruit bowl? By weight, four apples, a piece of watermelon or a lot of berries may come to the same mark on the grocer's scale. By volume, the apples will fill a larger bag than the berries. By price, you would pay more for a neatly-packaged import from a foreign greenhouse than loose produce at the farm gate. You could probably eat the whole berry, most of the apple, but only the flesh of the watermelon – although you could always decorate a cheap fruit salad with a few slices of something exotic.

Although much of this book is concerned with the technical constraints which dictate how much information a single CD-I disc can hold, it is essential to remember that the most important decisions are often creative rather than technical. The preparation of a fruit salad may depend less on the size of the bowl than on the cost of

the fruit and the tastes of the people who are going to eat it – and multimedia is, essentially, a fruit salad with many rich and diverse ingredients, which may be combined differently in every serving.

Domestic science is a useful preparation for multimedia, for a compact disc, like a fruit bowl, can hold many things. Multimedia platforms are not unlike television, video or publishing in its various forms, for the contents of any one package are subject to the limits of schedules, budgets and material resources, the technical demands of the medium and, of course, of the subject matter itself.

- There may be a wealth of raw material available, but the constraints of budgets and schedules often rule out anything which requires weeks of research, expensive copyright payments, or a great deal of travel.
- The source material which is available can pose technical problems. Images which are striking in their original form do not always reproduce well in other media – typically, because their colours are too strong or subtle, or because they are the wrong shape for the page or screen.
- The very choice of subject, too, dictates much of what goes into the disc. A programme about a young pop star draws on rather different sources than a documentary about the Russian Revolution. Many historical projects face a shortage of visual material from the past, and a superfluity of choice from modern sources. Much of what is attractive may also be under copyright.

Virtually every imaginative achievement, from a classical symphony to a Hollywood blockbuster, represents a combination of creative and technical solutions: what is new in the multimedia mix is a fresh range of technical choices which influence creative thinking. The finite storage capacity of the disc itself ultimately dictates how much material can be stored there. However, within that solid parameter lies a world of choice, where every decision is an element in that long calculation which determines what will eventually fit on the disc.

- On film or video, it takes the same amount of blank stock to record ten seconds of action, or a ten-second 'freeze frame' on a still image: ten seconds of footage, whether the image moves or remains motionless on the screen.
- With interactive technology, moving footage takes much more storage space and processing power than single frames, because the technology works in a fundamentally different way.
- At the same time, in CD-I, both sound and images can be recorded in a number of ways, each of which sets higher quality against greater storage space and

processing power – full-motion, full-screen video demands more than simple animation, stereo music demands more than plain speech.

Thus, the programme-maker must evaluate every creative decision not only within the familiar constraints of budgets and schedules, technical quality and clarity, but also in new terms which accommodate both the storage capacity of the disc, and the processing power of the player. The intricacies of these calculations (explained in Chapter 7, Audio and Video on CD-I) only concern the production team – but it is important that everyone involved with a CD-I project understands the basic principles which govern many essential creative and technical decisions.

It is also important, particularly for those who are less familiar with the production process, to recognize what a great role creative design plays in material which few users recognize as having much creative content at all – reference material, databases, even documentary and news reports. The skill and experience of the production team is often as 'transparent' as the technology in a good multimedia product. It is this very transparency which makes professional skills so valuable, for it requires both training and experience to recognize where subtle changes can enhance a presentation, and save both time and money.

The technical parameters of the CD-I platform are certainly important; what many newcomers should perhaps ask first is, 'What is this notion, interactivity?'

INTRODUCING INTERACTIVITY

On a conceptual level, the great challenge facing the designers of multimedia products, for consumers as well as professional markets, is achieving the right level and kind of interactivity for a range of end users, and a variety of delivery systems. The constraints here are imposed both by the nature of the programme and its audience, and by the structure of the delivery system itself.

- The design must provide the appropriate *level* of interaction for the content of the programme, the structure of the delivery system and the perceived abilities of the target audience.

This could be very low in a music video where viewers only want to select their favourite tracks, and very high in a simulator which must react as realistically as the complex equipment which it emulates. More will be demanded of managers on a training course than shoppers at a point-of-sale unit. Youngsters who have played

many computer games will positively demand more challenges than adults who are using a multimedia reference work for the first time.

- The design must provide the appropriate *means* of interaction for the content of the programme, the structure of the delivery system and the perceived abilities of the target audience.

The first CD-I projects were all, necessarily, developed for exactly the same delivery systems – those which Philips provided to developers before the commercial launch of the product. When several companies offer players and accessories to the consumer market, CD-I designers will face some of the same challenges as IV designers.

Of course, CD-I's functional specification obviates the spectre of hardware incompatibility which haunted IV designers. Nonetheless, different manufacturers will, at the very least, offer a choice of input devices (including variations on the hand-held thumbstick controller, as well as a range of keyboards, joysticks and other devices). Designers will have to meet the technical demands of similar products from different manufacturers, and the personal preferences of users themselves: some IV programmes, for example, offer the choice of keyboard or mouse, so trainees can use whichever is most familiar and comfortable.

Whatever the manufacturers offer, the wide range of screen sizes and audio output facilities in ordinary homes will inevitably affect the quality of the audio-visual programme, no matter how well it is designed and produced. Individual lighting conditions, acoustics, even climate will also effect the use of CD-I programmes in much the same way that they now influence viewers' perception and use of television. There are many factors which designers cannot control, but they can enhance the appeal of their programmes by offering audiences as many facilities as possible to adapt to individual tastes and physical circumstances.

INITIAL DESIGN

Chapter 9, Stages in Production, addresses the technical aspects of producing interactive video and CD-I, and transferring IV programmes to CD-I. However, before any of those activities begin, the production team must address a number of issues common to virtually all formal communication, from classroom lectures to TV game shows:

- Identify the target audience, and learn about them – their needs and abilities, interests and expectations.

- Establish a structure for the programme.
- Plan how users will navigate within that structure.
- Determine what material assets – audio, video, graphics, text – will fit that structure.
- Define the content of those assets, and the style in which they will be presented.
- Look for added value.

Much of the work at this level will determine the nature of the production activities to follow. A game usually depends on volumes of software programming, where a training or reference package requires more effort to create or secure the rights to diverse audio-visual material, and an entertainment package may be concerned primarily with securing material already under copyright. Understanding the true nature of the task ahead is essential to planning realistic schedules and budgets.

Instructional design

The phrase 'instructional design' entered the IV maker's vocabulary in the mid-eighties, when developers began to realize that there was more to interactive communications than video producers or computer programmers alone could necessarily deliver. The term now carries connotations of computer-based training and interactive video, which multimedia designers eschew, but many of the fundamental principles of instructional design are relevant in any platform, whether the end product be a children's game, an electronic brochure, or a training package. Wherever knowledge or information is transferred between people, even through the medium of a machine, instruction lies at the heart of the communication process. Good design is the foundation of an efficient production schedule and a successful product.

Instructional design stands one stage back from individual tasks such as scriptwriting, graphic design or video production. The designer or team must think equally about the subject of a programme and its audience, its structure and contents, its presentation and style. Design at this stage typically:

- Determines the broad aims and specific objectives of the programme.
- Identifies the audience.
- Defines the content.
- Selects the assets.
- Organizes the structure.
- Establishes the style.
- Sets the evaluation criteria.

Prototyping, to test the structure at the most fundamental level, is essential in a project of any complexity or length. Typically, experiments with prototypes will reveal both the strengths and weaknesses of basic concepts and specific ideas. Prototyping may prolong the first stages of the project, but can both identify successes on which to build, and disclose problems when they can still be easily redressed.

In commercial environments, the basic work of the instructional design team often takes the form of contract documents such as the brief which the client presents to potential suppliers, and the proposals and treatments which they submit in return. These documents typically outline the essential stages in the research and production of a programme, and supply much basic information about its audience, content, structure and delivery. Where large budgets are involved, it is eminently sensible to base the contract on the instructional design of the programme – and to agree a fee and the assignment of rights should there not be a contract after the parties have shared all the sensitive and creative information needed at this phase.

Design of this kind is hardly unique to interactive programming. The same basic principles lie behind the preparation of virtually all formal communications, from the classroom to the showroom. The difference at this end of the market is time and money: so much more of both is seen to be invested in multimedia projects, that developers tend to pay close attention to work which is virtually reflexive in other fields. Teachers preparing lessons for the classroom rarely think formally of task analysis. Neither do corporate video producers with small budgets spend much on audience research.

Doubtless, most professional communications would benefit from more attention to the formal stages, but this is difficult to argue in corporate markets where decision-makers often understand the cost of personnel and material resources more clearly than the value of information. Fortunately, in the multimedia market, the business case often comes first, and this in turn can put the project on the firm foundation of research and analysis.

Designers must also think constructively about the difference between knowing, understanding and doing. Students may first acquire facts and theory, but must then be encouraged to experiment and to apply this knowledge to gain comprehension, perception and practical skills. Stimulation, feedback and reinforcement in their various ways all help trainees to analyse, synthesize and evaluate new information and experiences. Much has been written about instructional design in work dedicated to that topic alone, and nascent programme-makers are well advised to study this valuable discipline.

IDENTIFYING THE AUDIENCE

Audience research can determine the salient characteristics of those most likely to use or buy a programme, and needs analysis can define what they want or require.

In commercial markets, this usually involves analysis of sales figures and market research, as well as questionnaires or face-to-face interviews with consumers who use similar products, or who represent a desirable audience. (Perceptive research may find that the real audience, a strong secondary market, or a new target altogether, lies outside the group originally assumed to be the primary market.)

In corporate markets, research at this stage usually involves analysis of the employees or customers at whom the programme is directed. It is advisable to speak with managers, sales staff and others who work with the target audience, and with unions or staff associations, for they often understand a great deal about the real needs and abilities of their own colleagues, staff and customers.

Market research

Audience research can identify opportunities and determine constraints which affect products for mass markets. This often involves desk research into economic and demographic trends as well as direct field research. Sonic Images, for example, used the findings of a Gallup Poll to build the business case for their *Private Lessons Series* music discs: one in four Americans, it revealed, plays a musical instrument, and a third of those play the guitar. This represents a potential audience of 18.9 million, 72 per cent of whom are male, with a median age of 28 – good demographics for 'early adopters' of CD-I, especially when live music lessons cost from $18 to $35 an hour. This sort of information, which commercial market research firms have at the ready, is an excellent foundation for the business case.[1]

Equally, it is not pure chance that so many of the very first multimedia packages are about golf: the game is particularly popular in America and Japan, and has a large international following among people who spend serious money on golf products, lessons and holidays – and satisfy the demographics of the early adopter to a tee.

Golf also attracts players of both sexes and all ages at a time when one significant factor for the multimedia market is the changing demographics of the very countries where consumers are most likely to buy new technology. Computer games may be better than ever before, but there are relatively fewer young people in the industrialized world to want them; on the other hand, the teenagers of the seventies are now computer-

literate adults with disposable income and children of their own. When economic recession curbs their spending on holidays and cars, they may console themselves with a CD or video instead. Such trends can be important in new markets.

Professional services can be invaluable here: market research is also a discipline, and qualified researchers often reveal the unexpected where in-house services only confirm their own preconceptions. Good research can not only analyse what is there, but discover what is not – which may be precisely where the market gap lies. Sometimes, too, where important subjects are politically or culturally sensitive, perceptive research is the key to initiating debate and developing programmes which address the real issues: good professional researchers know how to recognize clues and introduce subtle prompts where necessary.

Demographics

In demographic terms, audience research should include not only physical characteristics such as age and sex, but also social indicators. This can reveal profound differences between home and work, for example, which can be equally valuable in developing a consumer product or an in-house training programme. What people do for recreation, what language they speak at home, and what religious or cultural affiliations may influence their perceptions, can be more revealing than their formal qualifications or job titles.

Conventional media have, necessarily, tended to take the majority view, or address the lowest common denominator, but interactive systems can, with good design, address the needs and values of much wider audiences. Interactive video has not been conspicuously successful in this, despite some positive discrimination and a handful of programmes designed to challenge cultural stereotypes. There is a certain irony in the reluctance of some publishers to include text in multimedia productions: aside from the instructional value to most users of reading and hearing the same information simultaneously, the choice of the written or spoken word makes information accessible to those with impaired hearing or vision, or limited language skills.

The very virtue of interactivity lies in the range of choices which one system can offer a diverse market. Social issues may not interest many commercial publishers, but the fact that many cultural minorities represent substantial niche markets ought to encourage creative thinking. Interactive multimedia systems could address wider audiences more effectively than any other product on the consumer market – but it requires a combination of sound research and creative talent to realize their potential.

Of course, whatever the findings of the audience research, interpretation is the final key, and that rests entirely with the production team. Most observers would accept CD-I Systems' definition of 'mass appeal software' as 'software that just about any consumer above the age of eight, regardless of race, creed, colour, sex, religion or national origin, would enjoy using'. However, some might dispute their conclusion, that the ideal subject for their first mass appeal project was ... casino gambling.[2]

Learning styles

Some understanding of pedagogic issues is important to all designers, whether the end product be an adventure game or a training programme. Children and adults, for example, tend to approach new experiences – learning – in very different ways. Children's abilities and perceptions change so rapidly that one publisher says 'a 17-year-old and a 70-year-old have more in common than a 5-year-old and an 11-year-old'.[3] A single programme is only going to satisfy audiences 'from 8 to 80' if it respects differences which age and experience often confer.

Adults particularly display an array of learning styles which can be isolated in theory, but are usually combined in practice. Theorists tend to quadrisect learning styles in tidy diagrams, but the definitions of the four sectors vary, and most people in fact display characteristics of one or two patterns, with elements of the other two. (The works of theorists such as Gagné and Kolb are often quoted by practitioners of interactive design, but any good academic bookshop or research library should yield shelves of books on learning theory.)

Some adults like to approach new situations spontaneously, others prefer a structured approach; some want guidelines, others prefer to make their own decisions; some only want information which they find practical, others enjoy hypothetical discussions. Learning styles largely determine how any one person functions within a team, responds to instructions, attends to detail, or deals with failure. Most people are easily frustrated or bored when forced to employ a learning style alien to their personal preferences, whether they are playing an adventure game or studying a new language.

Most children and many adults, also, tend to be concrete thinkers who need facts which relate to themselves before they can grasp or enjoy new ideas. Conceptual thinkers, on the other hand, can easily appreciate hypothetical ideas and conjectural arguments. The specialists in any production team must remember that it is their very skills which set them apart from the majority of their audience. Graphic designers by

definition can visualize concepts easily, and understand schematic diagrams with little ancillary information. Users with skills of other kinds may need a fuller explanation, or more background material, to make the connection between words and pictures, or grasp visual conventions.

Some few interactive video teaching and training programmes have addressed these questions by creating short games at the beginning of the presentation, which analyse each user's preferred learning style, and either recommend or simply present the appropriate route through the course for each individual.

Computer literacy

Personal experience strongly influences any one person's reaction to interactive systems. Computer literacy now represents such a range of experience that people who regularly use computers may love or loathe them, and approach new media with either perception. People who know computers only as word and data processors may not see multimedia systems as computers at all; equally, people with no previous experience of interactive technology may approach multimedia as a form of remote-controlled VCR. The first generation of CD-I products face many preconceptions, some of which may ask users to make trade-offs of their own, between the visual constraints of CD-I and the added value of interactivity.

First-time users will be persuaded variously by marketing and sales skills to approach consumer products, and by other pressures to use training and educational systems. In all markets, users can be significantly influenced by promotional campaigns and hearsay, before they have any opportunity for personal experience. Internal marketing (of, say, a new training system within a company) can have much the same effect as the commercial launch of a consumer product.

CD-I designers would do well to provide a choice of resources, both in the introduction to the programme and in its operation, to cater both for new users who need encouragement at every level, and the computer-literate who are already familiar with the conventions of interactive communications.

Self-paced study

In training and education, users may be obliged to work with the system, but motivation is still important – and the design can do as much in a training centre as a museum to engage and sustain users' interest. In schools, colleges and training centres, users may

be motivated by ambition, guidance and peer pressure. Consumer products for home-study or self-improvement cannot count on any of this, and must motivate users who are not driven by external demands.

If users are to benefit from distance learning, academic prowess is not so significant as experience of self-paced study, or responsibility for one's own learning. Further and higher education, where students are responsible for many decisions about what they study and how they work, develop these skills. Many of those familiar with conventional classroom training – whether in school or training centres – have little experience of self-paced study and may need extra support and guidance. Whatever the relevance of previous education and training to the subject at hand, it is important to determine whether the typical user is likely to be comfortable with technology-based training, and open or flexible learning – and to provide resources for those who are not.

Designers must also understand what other demands and pressures may influence any one user's behaviour and response to the programme. These include practical questions such as peer pressure, other demands on users' time, or the desire to gain new skills or qualifications.

Where a new multimedia programme is based on material developed in another medium (even an older CBT or IV package), a critical analysis of the contents and structure of the earlier model may suggest fundamental changes which the transition to a new platform could effect. Full-motion, full-screen video of course requires special treatment, but the essential instructional strategy of the older programme often reflects the constraints of the original medium as much as the real needs of audience.

There may also be implicit political questions – particularly in work commissioned for a specific environment – to which the designer must be sensitive. These include corporate messages and objectives (which may not be complementary to the programme as a whole) and, of course, 'hidden agenda'. It is always worth securing the support of the local union or professional body, not only to promote good industrial relations, but also to discover information which managers might not even think to provide. There is an element of investigative journalism in instructional design, for the client's brief may not tell the whole story.

All this information – from the demographic profile of the target audience to a basic understanding of behavioural psychology – helps the instructional designer to interpret the real aims and objectives of the project and the needs, abilities and interests of its audience. This is the foundation on which the structure of any individual programme is built, to present its contents and lessons to its audience in a format which is versatile, instructive and entertaining.

Ergonomics

It is also important to understand both the physical environment and the professional support which users can expect in any context. For self-paced study, this may range from a dedicated training centre to a training room in the workplace to users' own homes. The likelihood of finding professional-quality equipment, purpose-built furniture, freedom from distractions and the support of a tutor, decline proportionately from the training centre to the family home.

Many multimedia developers say that consumer products will have pride of place in the family's living room, but many are likely to end up in bedrooms and playrooms. Those which are connected to the TV may have to compete with the broadcast television and video for attention; those in other rooms will attract more dedicated use. Public information systems face different challenges – not the least, in designing customized housing which is both functional and attractive. Interactive systems are generally used by individuals or very small groups, which means that, on a busy day, no more than a fraction of visitors will get hands-on unless the systems are specifically designed to encourage high through-put. This, in turn, severely restricts the potential for sustained interaction. Some technical aspects of these questions are discussed more fully in Chapter 10, Screen Design.

ESTABLISHING A STRUCTURE

It is useful from the outset to think conceptually about the physical structure of the programme. Most interactive presentations are ultimately hierarchical in design, however flexibly they may be presented to the end-user.

Information is typically arranged in layers or levels, from the broadest to the most specific, and in discrete units which address a common theme at graduated levels of detail. In a flowchart or content map, layers or levels can be represented horizontally, and sub-divided vertically into individual components. (Introductory sequences such as opening titles, credits and menus usually lie outside or above the hierarchical structure.) A typical training course may appear as in Fig. 5.1.

This hierarchical structure usually also represents the foundation on which conventions for screen design, content and navigation are based. All the information in any one layer, for example, may employ conventions to identify the level of detail or complexity which users can expect to find there. Typically, the appearance of all text screens will be uniform within any one layer (and slightly different between layers),

while all the information in any one module may employ other conventions (particularly, colour-coding) to establish continuity.

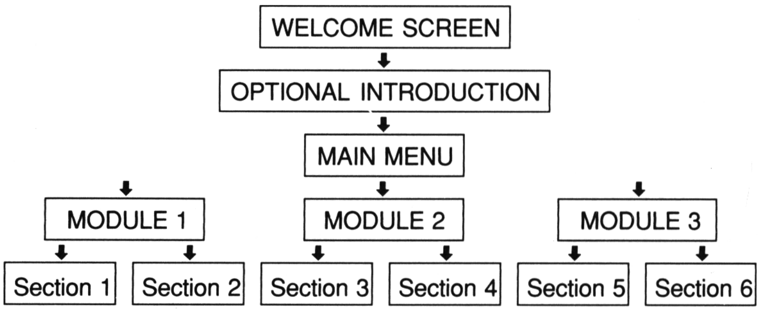


Figure 5.1: Establishing a structure

- *For the production team as well as the audience, it is important to distinguish separate layers or types of information, and to employ these categories consistently.* Various components are typically described as articles, chapters, essays, exercises, items, lessons, modules, parts, sections, segments, subjects, themes, topics, units or volumes. There is no universal convention to define any one term, or its hierarchical relationship to another – one project may divide a chapter into several parts, another may put several chapters in one part. However, naming conventions should be logical and, where possible, should reflect terms or concepts appropriate to the subject matter.
- *In naming individual segments a combination of structural and descriptive terms shows users where they are in the programme, and what any one segment contains* (e.g. 'Chapter 2 – Useful Phrases, Lesson 1 – In the Restaurant').
- *Complementary material such as printed user's guides or workbooks, should maintain the same structure, terms (and, where appropriate, visual conventions) as the programme itself, to reinforce key points in users' minds.*

These devices help users to establish, often unconsciously, a mind-map of the programme. The consistent use of keywords, colour codes and other conventions help users to perceive patterns, to place new information in context and to make more effective use of the interactive presentation.

NAVIGATION

Navigation lies at the heart of all interactive design. The challenge is to help users to develop a coherent mental image of the programme's structure, while still allowing them to move about easily within it.

The intellectual trade-off here is between the convenience of leaping directly from one place to another, without a thought for the journey, and the confusion this may create in the mind of users who are trying to grasp the structure of the programme. Designer Theo Wright quotes the user who remarked bemusedly, 'You hit the 'home' button and suddenly you're not in Kansas any more'.[4]

Wright's observations of hypermedia programmes now in the market has led him to emphasize the importance of symmetry. For example:

- *Users should never have to go further in to get further out.* (Conversely, of course, users should never have to go further out to get further in.)
- *Users should always be able to come and go by the same means* – the same route that lead to the end of the road ought to lead back to the last fork or turning (except, perhaps, in the magic woods of an adventure game, where players are supposed to be mystified).
- *Users should not be offered choices and options which appear to have no effect on the screen, or do not relate the segment of the programme currently in use.* It is often useful to display menus in the same way every time, and simply to disable options which are temporarily inactive or inappropriate (typically, by lowlighting or in some other way visibly distinguishing them from those which the user can employ in the given context).
- *Every individual feature and segment of the programme should have one clearly identified name, and one name only.* Even if 'Menu' and 'Contents' are often synonymous, one or the other should be used consistently.

Many of these observations would be too obvious to mention except that so many discrepancies can be found even in well-made programmes. Some continuity errors inevitably arise over a long production schedule, but that in turn makes the case for rigorous project management and detailed documentation, to identify and rectify inconsistencies as they arise. Problems of another kind often occur when the production team gets so close to the programme that they fail to see where features which are thoroughly familiar to them are too complex or esoteric for new audiences. This, in turn, makes the case for early, frequent and regular cold testing with real users.

Other general principles may be drawn from the model of popular computer applications software. For example:

- *Every action should have a logical reverse or re-action* – in computing, precisely the same action often has directly opposite consequences turn-and-turn-about. The same action may create an effect and, if users do not like the result, immediately undo that work and leave the image on the screen as it first appeared (although users may have learned something from the experiment). In simple interactive systems, this may be no more than a toggle between, say, 'pause' and 'play', so long as it always works in the same way.
- *As far as possible, the same routines or options should work consistently throughout the entire programme, or even within a series of related programmes.* In *Caesar's World of Gambling*, for example, the same procedures apply to starting every game, so players can move from one type of game to another as easily as possible.
- *The same action should produce the same results in similar contexts.* This extends to the use of the same conventions (let the same shortcut always effect the same reaction), and the same degree of effort (a similar effect should not require two steps in one part of the programme, and three in another).
- *The time frame or rhythm of similar segments should be comparable wherever possible.* There are many technical constraints which affect the rate at which information appears on the screen, but users should not feel that the same action produced faster results in another context for no reason which they can immediately perceive. Discrepancies in response times particularly are often perceived as malfunctions or machine errors (both by inexperienced users who expect instant results, and by those whose expectations are based on relevant experience).
- *The interactive programme should not ascribe unusual meanings to common words, nor coin peculiar acronyms where familiar terms would suffice.* Training packages, of course, benefit from using specific terms, in context, that the trainee will encounter on the job. And in games, where users can be expected to spend many hours in a parallel universe, many players positively enjoy the treats of a secret language. But the majority of consumer and professional applications should be designed for a club that anyone can join.

Clearly, creativity and consistency are both important: users must be intrigued, encouraged *and* challenged. If the package asks too much, users are quickly discouraged; if it offers too little, they are soon bored. New users need reassurance –

they must achieve results quickly, and be encouraged to explore. But the programme should always be just ahead of its users so that, as they become more competent, it becomes more challenging.

- *It is often helpful to provide a brief, linear introduction which users can watch from start to finish (perhaps, with a few short practice exercises) before undertaking the main programme.* This is useful for first-time users even in a corporate or consumer market, and essential for casual users at an information system or marketing presentation; it may also help occasional users who have not seen the programme recently, and have forgotten its conventions.
- *It is also useful to leave a metaphorical trail of pebbles along the path so that users can back-track to the last interesting fork or crossroad, and explore another route.* In CD-I, the electronic equivalent of notches in the trees usually takes the form of 'bookmarks', which allow the user to mark an idea or subject of potential interest *en route* to another piece of information, and return there subsequently, to begin another journey – a service not always afforded by the human mind.
- *Most users also appreciate some form of map or gauge to indicate where they are in the programme and how much remains to do or explore.* This may take the form of a map or chart, which colours or flags those segments which have already been explored or completed. Self-paced study usually predicates against setting time limits here, but it is often possible to provide a bar chart to indicate the relative length of each unit, so that users have a personal point of comparison after completing one (or even part of one). Similarly, the relative volume of the programme already completed may be represented as a point on a sliding scale, so users can hit a key on the control panel, for example, to see how much of the current lesson has been completed, and how much remains.

Applying general principles to individual projects, of course, depends greatly on the perceived needs and abilities of the target audience. Museum Director Peter Lewis believes that 'the visitor should not have to go deeper than a main menu and one sub-menu to access a program, and they must be able to stop at any time and return to the main menu either directly or via one sub-menu. This [should be] very well sign-posted on the screen'.[5] This structure would be restrictive in a professional reference tool, but respects the needs of the casual user who wants instant access to information, and the freedom to browse and explore.

Of course, once users have mastered the basic navigational skills to move about the programme freely with confidence, simple routines can become frustrating if they

impede direct access to specific activities or information. The answer may lie in a two-tier structure, with shortcuts for experienced users (such as computer applications software often provides).

But, at the same time, as the pursuit of information and ideas becomes rewarding in itself, the tools at users' disposal should be as efficient and 'transparent' as possible. (For the museum visitor, Peter Lewis observes, 'Familiarity breeds contentedness'.) The key to success lies in careful analysis not only of the programme's content, but of the needs, interests and abilities of its target audience and – as more examples of interactive multimedia programmes come onto the market – of the strengths and weaknesses of the models already offered.

Metaphors

One of the single most obvious and effective trends in interactive design during the late eighties was the discovery of metaphors to replace or at least enhance purely text-based navigational aids.

Large menus such as those at the very beginning of a programme, which must often provide a comprehensive overview of a complex structure, can be extremely difficult to design in words alone. It is particularly difficult to design a text menu which does not suggest a rigid hierarchical structure, for that is how we are most accustomed to seeing and using tables of contents or flowcharts. An interactive programme is more likely to encourage users to pursue free associations if it avoids all reference to familiar, formal hierarchies.

The radical solution adopts a single, versatile metaphor which may use text to label or clarify individual elements, but primarily employs non-hierarchical visual stimuli and clues. One of the most common metaphors in management training, for example, is the office itself: in an induction course, for example, the new employee may metaphorically visit the 'Personnel Department' for information about terms and conditions, 'Head Office' to learn more about the structure of the organization, or 'The Post Room' to see how internal mail should be addressed and circulated.

In the 1991 CD-I version of *Van Gogh Revisited*, developed for PIMA's ArtSpace Production Group by Drs. Jean-pierre Isbouts (who produced the original LaserDisc in 1982), users begin with a drawing of the town square, where a visit to 'the gallery', for example, leads to a collection of still frames. Many users of the videodisc version were slow to discover this and other reference material at the end of the disc (and reluctant to explore, when to call up a single frame required a five-digit code and two-

key retrieval routine on a hand-held keypad). Most simply used the familiar scan button to move around the disc in fast forward, and ignored both chapter numbers and frame codes.[6] In the new version, a thumbnail of each painting hangs on the gallery walls, and users have only to select this to see the whole image on the screen. The use of metaphor has transformed this portion of the disc through instructional design.

Metaphors can be more efficient, accessible and entertaining than conventional menus and tables of contents. However, the metaphor must be logical, versatile and appropriate to the context of the programme.

- *Too many metaphorical devices, or fanciful associations for common objects, can be confusing, as can a mixture of metaphors in close proximity.* Devising extended metaphors can be great fun for the project team, but a metaphor which is pushed too far may easily become too cute or intrusive for the audience.
- *To keep the appearance of any one screen simple, and provide optimum versatility, successful metaphors typically employ both objects and locations.* Typical examples include a telephone to hear an audio message, a door to move to another part of the programme, a building or village to represent the whole programme, and a room or place to represent any individual segment.
- Metaphors primarily employ visual prompts such as icons or objects, but text labels and audio prompts can usefully clarify the name or function of the item where this may not be immediately apparent. These may be activated only when an icon or object is selected. When users are familiar with the programme, its metaphors effectively become transparent and labels or prompts can be intrusive; however, first-time users, or those who haven't seen the package for some time, will appreciate optional *aides-memoire*.
- *It is important to employ consistent visual conventions in the design and use of icons and objects within the metaphorical structure.* Graphics with metaphorical functions, for example, should respond like other icons or objects when touched by the cursor or selected for action – that is, light up or charge colour, flash or sparkle as the conventions of the programme dictate.
- *Like other items in a typical computer menu, icons or objects in the visual metaphor may change in appearance to indicate whether they are active, or can be employed, at any given moment in the programme.* As a general rule, every object in a scene should have a function; alternatively, those which can be employed should look distinctively different from those which are merely decorative, or temporarily inoperative. Highlighting active objects, and lowlighting inactive ones is a useful convention.

- *Equally, if an object can be employed only for some functions, it should stand out when it is active, and look different again when it is temporarily inappropriate to the activity at hand.* In an adventure game, for example, the telephone receiver may rest in its cradle when the player can call for help, but dangle over the edge of the table to indicate that the line is dead.

The transition from text to visual metaphors, and the rise of graphical user interfaces, represents a positive challenge to conventional design strategies. The key for the innovative designer is to recognize where conventions can be challenged – and where they should be respected. Timelines and titles that scroll across the screen, for example, are a logical alternative to screens which scroll up and down. Large star-shaped cursors are attractive in children's programmes – but impractical in programmes where one point alone is needed to specify selections from the screen.

As metaphorical designs become more common, they may have to display a judicious degree of originality, too. The office metaphor is already familiar, and may become confusing to users who see two or more programmes ascribing different functions or values to the same common features of the office environment. Thus, while visual metaphors are highly effective, text labels or audio prompts provide valuable *aides-memoire* within the specific context of the programme.

Hypertext

The term hypertext was coined by a pioneer of modern computing, Ted Nelson, who first used the term in 1965 to describe ways of linking disparate bodies of textual information so that users could freely pursue common ideas or themes across several separate databases.

This is the idea behind seminal software products such as Apple's HyperCard, which combines text, graphics and sound in a program based on the principles of a conventional card file. Each individual unit of information (typically, a piece of text with an illustration, and perhaps some sound) fills one 'card' on the screen. Each card also carries a least one 'hotspot' which users have only to select to execute an action or move to another card.

Typically, in a computing environment, users select items by pointing-and-clicking with a mouse, although many public information systems and some training packages employ other devices, including touchscreens, roller-balls, buttons and keypads. The hotspot itself may be identified by a word or phrase, which stands out from the body of the text (being in a different colour, for example, or UPPER CASE). Equally, the

hotspot may employ a small pictogram or icon, which symbolizes a function which can be performed when that item is selected.

This, of course, is the paradox of hypertext (or its successor, the more diverse hypermedia): users can move freely through the entire database, following ideas in various directions and making spontaneous connections – but only insofar as the design team has defined the content of the database, and provided the hypertext links to facilitate those journeys. If the designer has not built the road or the bridge from one place to another, users may have to find the indirect route, perhaps without signposts, or miss the connection altogether.

Hypertext aims to replicate the free associations which naturally occur within the human mind, but in practice it is a specific set of human minds which define what any one hyperworld will contain, and how it will be governed. Designers themselves are seeking new approaches here – for example, by offering users the facilities to create their own links, or designing systems which will automatically generate new links as the user explores the database. On a more modest scale, on CD-I, the original design for the *Grolier Multimedia Encyclopedia* comprised six linked databases:

- Knowledge Explorer presents a series of 25 audio-visual essays, of about five minutes each, which provide thematic introductions to the contents of the disc. Users can interrupt the linear presentation at any time to find out more about any one topic. The essay on Africa, for example, can lead to the discovery of ancient Egyptian history, or the wildlife of the savannah.
- Time Machine provides another approach to the larger database by arranging important events on a dynamic timeline, which users can interrupt to learn more about any one event, and related topics.
- Factfinder uses text retrieval to provide direct access to specific data on the disc. The menu combines alphanumeric keys to spell out individual words, plus an index in 26 metaphorical 'volumes' which lead to alphabetical lists of all the articles in the encyclopedia. Keyword searches may be the simplest of professional database facilities, but for consumers unused to databases of any kind, they represent added-value unparalleled in books or video.
- Picture Bank comprises 12 image databases, which bring all the still pictures on the disc into a dozen thematic collections.
- Map Bank, similarly, provides direct access to all the maps on the disc as an interactive atlas, with features including national flags, a global view and a comparison of land mass between the US and other countries, to help users put maps in context.

- Brain Games draws on text and pictures to create 2000 questions in a series of quizzes which users can play for entertainment, and as a stimulus to learn more about unfamiliar information and ideas.

This design also provides a series of 'mini-menus' to support the facilities available within any one part of the presentation, as well as an 'Encyclopedia Trail' with bookmarks to retrace a line of inquiry and explore other branches, as well as instant help facilities in all parts of the programme. Six personal 'guides' (including Einstein and an astronaut) lead conducted tours through selected topics, and interactive graphics allow users to experiment with objects such as an abacus directly on the screen. Obviously, many of these facilities ultimately produce the same material from the disc – the challenge to the design team is, first, to provide that information and, then, to devise an appropriate variety of means for users to find and explore the collection.

DATA MANAGEMENT

Chapter 8, The Production Team, describes some of the professional qualifications which complement interactive multimedia design skills. Metaphorically at least, the designer also needs the organizational skills of a master restaurateur, to devise menus, manage a kitchen and provide a variety of dishes to the right tables in prime condition. It's no good sending the dessert before the main course is finished, or to leave the diners waiting for the vegetables while the meat gets cold. Creative issues notwithstanding, the interactive multimedia designer must learn to manage the volume and flow of data which the system demands, and to balance every creative decision against the technical demands of the platform.

Interactive multimedia systems typically store data of different kinds separately, and not always in adjacent parts of the recording. This affords the designer and programmer many creative opportunities not enjoyed by conventional programme-makers, but it also demands that all the disparate components which may be presented at any one time be drawn together at exactly the right time and in the right order. Multimedia systems which store sound and pictures separately even face some of the same challenges as the very first talkies, in synchronizing lip movements and speech (albeit with much more versatile resources).

CD-I's several golf programmes, for example, include many examples of synchronization of the most obvious kind. At each stroke, the golfer in the foreground moves, to the sound of the club hitting the ball and, soon after, the response of the crowd and

commentators. The background immediately changes to reflect the new position of the ball, which may also be shown on an adjacent overview of the hole. This may involve animation in one plane, graphics in another, at least two short sound bites (one for the ball's being hit, another one or two for crowd sounds and commentary), and of course all the appropriate commands to the system which control the flow of the programme.

To ensure that all these data can be collected from their storage point on the disc, passed through the data channel and on to the delivery system, the designer and programmer must also pay close attention to quality levels. High-quality graphics leave little room in the data channel for audio, text and control programs. Rapid animation may demand compromises from the audio data. If moving images occupy two-thirds of the data channel alone, all the associated audio must necessarily be presented at a level which demands one third or less – probably less, if any other information is to get through. Fortunately, there are tools to assist the designer in making these calculations, and these are discussed in the Chapter 9, Stages in Production, and Chapter 11, Programming.

How these demands are met creatively will vary considerably from one project to another, and will in some part be dictated by the very nature of the programme. An encyclopedia or reference work typically demands large volumes of sheer data storage, principally to support text files and illustrations, and to provide good and flexible retrieval systems; a music programme by definition will be given over to large quantities of high-quality audio, while a game demands lots of interaction and a number of outcomes for almost every action. The complementary features of the programme – audio and moving footage in the encyclopedia, text and graphics in the music programme or the game – must be accommodated within the resources which remain. Programmes which have no such inherent strictures are a blank canvas indeed, which the designer must fill with meticulous attention to detail.

Is it broken?

Interactivity is entirely concerned with the flow of information between people and machines. Users are presented with choices, options and decisions, and soon learn to expect a quick and coherent response from the system which provides them with information. The visual expectations raised by television and computers set the multimedia designer another challenge: a static image, a blank screen, and more than a moment's silence suggest to many users that something has gone wrong. To keep users engaged, and to provide constant feedback, it is useful to:

- *Ensure that users are required to interact with the system at regular (but not too predictable) intervals.* Interaction should always be relevant and productive, and certainly not gratuitous, but frequent enough to keep users alert and participating.
- *Provide visual (and, perhaps, aural) responses to every choice which users make during interactive sessions.* Typically, this means that hotspots such as icons or menu items change in appearance when they are touched by the cursor, and again when they are selected to effect some action. Sound must be used more discreetly: funny noises soon lose their novelty and can, with too frequent repetition, become extremely irritating.
- *Provide a short gauge to reassure users that the programme is still active during a brief pause (for example, while the system is retrieving and processing data).* This might take the form of a clockface with moving hands, a gauge which moves or changes colour to indicate what percentage of the activity is completed, or simply some small moving (usually, spinning) object which demonstrates that the player is still active.

As users move the cursor around a menu screen, for example, each active object which it touches will typically 'light up', change colour or intensity, or in some other way distinguish itself from the rest of the screen. When an object is selected to effect some interaction, it may 'flash' or otherwise change briefly in appearance, and an audio prompt may confirm the choice.

- *Where many interactions may occur in a single session, it is important that these responses are not intrusive.* Audio prompts, particularly, may be optional, to be turned on and off by each user, at any time.
- *It is tiring to interact constantly, and users appreciate short breaks – to watch a picture essay, perhaps, or some video.* However, even a minute of uninterrupted linear activity in an interactive programme can seem long indeed.
- *Even a picture essay needs to refresh the image on the screen many times a minute.* Some designers suggest that a new still image be supplied as often as every three seconds, to concentrate viewers' attention on the screen.

If a choice occasions a pause between scenes, while the system searches for new information and prepares these data for output, it is also important to reassure those who are waiting in front of the screen that new information is on the way.

- CD-I systems will not present a blank screen unless specifically requested to do so, but it may still be useful to disguise the transition between scenes by devices

such as single-plane visual effects (described in Chapter 7, Audio and Video on CD-I), or by starting the new segment as soon as either the sound or the pictures are ready, and supplementing the first by the second as soon as possible. These techniques are often used in television, and can be quite attractive; alternatively, a short sound bite can distract the viewer's attention during the transition from one segment to another.

- Some early CD-I applications simply revert to a rapid sequence of the 16 basic colours on the backdrop image plane during long pauses, although this (having no precedent in television) can be alarming to new users.

Equally, if users do not respond as expected, it is important to provide prompts (ideally, which take the same form at all points in the programme, but remain logically consistent within any one scene).

- *An audio prompt, after a pause of some seconds, may remind users that a response is required.* It may be useful to reserve the use of audio prompts for important messages or reminders, so that users learn to associate the sound of the prompt with a call for action (or even a warning, where users are asking to do something risky or irrevocable).
- *It is important to consider what may distract users from the screen at any one point.* For example, users at a public information or marketing system are less likely to be interrupted than someone working in the office or at home.
- *Equally, any application that is likely to be used by groups – in training, education, entertainment or marketing – should allow time for them to discuss what they are doing.* This typically takes the form of a 'time out function' or pause, perhaps with a time limit or a prompt to ask if users want more time.

In marketing or public information services, it is usual for the system simply to revert to its welcome screen or attractor loop if it is left unattended for a given period of time. In professional applications, it is common for a 'screen saver' to dim the screen or display a simple moving graphic during long pauses. This prevents the last static image on display from temporarily 'burning' its image into the screen (a phenomenon observable, for example, in many ATMs and public information terminals).

A screen saver also serves as a reminder that the system has been left unattended: a touch to the keyboard or mouse restores the last image in the main presentation. Consumer applications for the home may employ either strategy, depending on the nature of the programme.

- *A simple game may revert to the beginning if left unattended, but anything in which users have invested some time and effort should remain intact until the system is turned off, or another instruction is provided.* A screen saver can be employed during long pauses, both to spare the tube in the monitor, and to indicate that the system has been untouched for some minutes.
- *The screen saver may simply dim the last image on the screen, without changing the display there, to signal that the system is waiting for instructions.* It may alternatively display a different screen image, perhaps with a message to explain how to retrieve the main screen again (typically, by moving the mouse, or using the keyboard or hand-held controller).

Alternatively, a formal time out function is useful in any programme where users may be called away, or simply want a break from the screen without sacrificing all that has been achieved so far.

- *'Time out' should offer at least a pause, which allows users to resume without interruption at a single stroke of the remote control unit, mouse or keyboard.*
- *It may also be important to provide bookmarks, prompts or student records which allow at least users to leave the programme, switch off the system, and start again from the same point in another session.* A text or audio prompt, a graphical 'route map' or record of use may help the user to re-enter; passwords can protect individual records where the system has many users.
- *No system should automatically change state without warning users what is about to happen, and providing an alternative course of action.* Complementary text and audio prompts are appropriate here, to ensure that users (who may not be looking at the screen) always get the message in time to take action.

The same basic principles apply to many elements of the interactive design: virtually all activity should be interruptible, and users should have a clearly-marked exit route, as well as appropriate options for direct re-entry.

CREATIVE CHOICES

In multimedia applications, as in conventional television or video, creative choices often govern the way in which information is delivered or enhanced. The decision to use speech or music, text or graphics, still pictures or moving images, lies both in the inherent content of the programme and its design.

Sometimes, information clearly must come from a specific source – excerpts from a political debate, say, or pictures of a fashion show – but a great deal of the information which we receive from television and video is not distinctly tied to any one form of presentation.

Clearly, entertainment such as drama, sitcoms, soaps and game shows depends almost entirely on moving pictures – usually, of people consciously performing within professionally-dressed sets or locations. Although various production techniques are used to enhance these pictures, aside from the elaborate design of titles and credits, special effects in entertainment programmes principally strive to make the artificial look as realistic as possible. Many viewers now understand, for example, how separate shots are combined to suggest that actors, safe in the studio, are really clinging by their fingernails to window-ledges, but knowing how it's done rarely spoils the audience's enjoyment.

The evening news

Few viewers think twice about the many effects used to enhance the information which they receive from news, public affairs and documentary programmes. A brief critical analysis of an evening's television is enough to demonstrate how rarely content alone dictates form. A change in the tax laws, for example, has no inherent visual content, and could be adequately explained in a good radio programme. The corresponding newspaper story might include a few graphs or charts to illustrate the probable consequences of the change. It might also include a photograph of the senior politician responsible, and perhaps a few interviews with people whose personal finances will be affected by the new laws.

Already, the coverage of the story has moved from pure reportage to editorial and interpretive comment. This all helps us understand the news, and decide how it will affect us, but the story which you could have heard from your neighbour in the street has already become complicated, visually and intellectually.

When the same news reaches television, with its inherent demand for movement and variety, a full battery of effects will be deployed. It is common now to have two newsreaders working in tandem, and to use two or three studio cameras to show them at different angles. Some programmes deliberately cut to wide shots of the working studio, or use a long shot of the newsroom itself as a backdrop. A small window often appears behind the newsreader, with a photo, graphic or caption to identify the main subject of the story being reported. Information of other kinds may appear in corners

around the screen: the name of the programme or channel, or a clockface showing the time.

A television story about new tax laws could include computer graphics in the form of charts and graphs, footage of the speech in which the change was announced, interviews with members of the government and their critics, comments from the programme's own financial and political editors, opinions from the inevitable experts, and visits to offices, shops, factories and homes to illustrate how business, commerce, industry and common people received the news.

One story has now drawn on the skills of a large team of reporters, researchers, camera crews, graphic artists, studio technicians and editors. It has probably combined live broadcasting from the studio with footage shot and edited earlier that day, archival material (including still photos and moving footage), and a range of new images, both photographic and computer-generated.

Many news programmes usually also include reports from national and foreign correspondents, and even reconstructions which hardly differ from drama. Many production techniques will have been used to combine all this information smoothly. Little wonder then, that corporate video alone easily costs £2000 a minute to produce, and that a minute of international TV news can cost as much as a whole corporate video programme – and that putting all this together within rigid deadlines requires a team that is highly efficient *and* creative.

The challenge of television

The economics of multimedia production are rather different from those of broadcast television, or even corporate video, but the same principles apply – and television will undoubtedly set the standard by which many people approach new media such as CD-I. Television, rather than computer games or CBT, should certainly set the standards to which CD-I designers aspire. Fortunately for the multimedia designer, television in the eighties began to break away from full-screen full-motion photographic images, to reflect visual conventions from other environments (notably, computing), and to explore the potential of digital video and a great variety of graphic images.

There is particular evidence of this transition in the range of animation now seen in advertising, news and public affairs as well as children's programmes and short films. Most viewers now realize that animation describes not only cartoons, but a wealth of styles, techniques and media from finger paints and shadow puppets to three-dimensional claymation and dynamic computer graphics.

Good special effects, too, really only came to TV and video within the last 10 years, as reruns of the science fiction or pop music programmes of the seventies readily attest. Television now uses many of the visual techniques common to computer games or interactive video: superimposing blocks of supplementary text over moving pictures, for example, or dividing the screen into a combination of text panels and video windows. Where non-broadcast media once modelled their work closely on television styles, there is now a lively trade in ideas between broadcasting and the other audio-visual media.

All this is to the good for true multimedia formats, for the transition from TV to other forms of presentation is no longer as sharp as it once was. On the other hand, we still tend to think of the TV screen primarily in terms of full-screen, full-colour moving pictures with sound, and to see everything from animation to video windows as variations on that theme.

A critical analysis of news or documentaries reveals how profligately moving pictures are used in both television and corporate video simply to add interest to information with no inherent visual content. The hypothetical broadcast on the tax laws could well include several shots of a crowded street, or goods in the shop windows, merely to give the viewers something appropriate to watch while they *listen* to the news being read. This is a creative decision much affected by the basic needs of broadcast television – which must fill the screen with pictures, and keep the programme moving – but it has shaped the expectations of all those who watch TV, even when they are looking at other media.

Worse yet, expectations are higher where television is better. Multimedia producers have a wide choice of creative options, and face much different technical and economic constraints than television producers, but they need a radically different approach to programme design to demonstrate how effective other styles of presentation can be.

Imponderable: cultural issues

CD-I is, technically, an international product which can distribute one disc to markets from Tokyo to Rome. Television, with a few technical adjustments, has achieved much the same penetration, as have audio recordings of all kinds. CD-I programmers may benefit from the cultural inroads which TV in particular has already made, for most of the first titles in the CD-I consumer catalogue were produced in the United States, and many carry cultural indicators which may influence their reception in international markets.

Speaking at Microsoft's first European multimedia conference, Cherrill Smith of Stratos, a Polish CD-ROM distributor, observed that 'Understanding the culture of the country is crucial to success, and in a market which remains unclear, a broad product positioning is important'.[7]

What is appropriate or acceptable for any one market is notoriously difficult to judge: some television series which were modestly received on home ground become cults in foreign environments, while blockbusters meet with indifference or hostility. Equally, the values or customs of one culture can be confusing or even offensive to others – gestures, particularly, have critically different meanings in different parts of the world, colours have different associations, and the visual conventions of print and television can be different, too.

Questions of racism, sexism, ageism, and class consciousness have diverse applications from one region or country to another. Designers who mean to address international audiences must understand cultural values and differences – which can be profound even within Europe, let alone between continents. Even within political borders, differences between regions can include aspects of language such as dialects and vocabulary, as well as social values in the home, the street and the workplace.

Humour, too, is utterly subjective – if the joke backfires, it can alienate an audience entirely. To take one offbeat example from interactive video, in a programme on *Basic Automotive Electronics* for the Ford Motor Company of America, Jasmine Productions elected to characterize the 'many personalities of electrical theory' as film figures from Hitchcock and Bogart to Crocodile Dundee and Rocky Balboa. General George Patton rubs shoulders with John Wayne, and the climax of the course allows the successful trainee to meet lookalikes of Michael Jackson, Princess Diana and Elvis Presley.[8] There are designers who would question this rather confused paean to celebrity, and the instructional values which it endorses, but the course was popular with its target audience. A cross-section of Ford's technicians gave it eight-out-of-ten for clarity, and most said it was easy to watch and understand, and that they would like more material developed in the same style; a mere handful described it as stupid or childish.

Producers in other media have learned that the values and interests of the production team (or even the client) are not necessarily those of the target audience. The managers who commission the programme may be quite different from the workforce for whom it is intended. A successful project must look objectively at both the proposed content of the package, and the people who are really most likely to want or need it, and work constructively with that information to create programmes which are challenging and rewarding, entertaining and informative.

ADDED VALUE

Products for systems such as CD-I could, in addition to the audio-visual resources which consumers now take for granted, also offer features which represent unprecedented added value in consumer products. Even without the novelty of multimedia, many facilities which are common enough in professional computer software are still entirely new to the home entertainment market. One challenge for professionals accustomed to complex computer-based systems is simply to envisage this new environment from the consumer's perspective. One observer, Gabriel Ofeish, has reminded publishers that 'The computer base in the real world is Nintendo, not the PC ... we're beating the rug with a vacuum cleaner'.[9]

Indexes and searches

Consumers and professional researchers may be the two groups with the least and most experience of databases, but both may now reasonably expect the same range of facilities. The interested amateur with an electronic encyclopedia, and the postgraduate student with a research project, both need free-entry retrieval systems which respond 'intuitively' to the user's choice of words and phrases, and provide prompts and facilities to refine the search, and annotate its results.

Typically, this means that, to effect a search, users should have easy access to a menu or 'dialogue box' which allows the free entry of key words or phrases into a standard structure for data retrieval. In a programme of any complexity, this same menu should also provide options to refine the search by stages – for example, to mark all references of potential interest, or to rank the most likely references so that they can be explored in order, and users can return to the menu screen after each investigation. In a database for professional researchers, these facilities can be many and various, and a semi-intelligent system will even deduce new key words and phrases to suggest other lines of approach.

A range of facilities at this level puts as much onus on the programmer as the designer. The many databases now in circulation have established common practices in professional sectors, for database designers and users alike. However, where users are not expected to have the skills and patience of a professional researcher, the designer must provide the right facilities for the target audience. Good retrieval systems should free the inquiring mind to pursue and interpret information with tools which make that pursuit as easy and profitable as possible.

In a public information system, this usually involves some means of refining the search so that users need make only a few simple choices to reach a manageable number of options. This is a question of content as much as design: too many similar entries simply confuse users if there is no clear way of distinguishing the unique properties of each at a glance.

The critical task for the production team – which, at this stage, might involve the content providers, the scriptwriter and the designer – is to step back and view the information from the user's point of view, to determine what is really most important to someone who wants to extract information quickly according to practical criteria. An alphabetical list of restaurant names is only useful to people who know where they want to go, and just want the telephone number. Visitors to the city are more likely to choose a restaurant by the type of food it serves, its location, atmosphere, opening hours and price range: 'Italian, Kensington, casual, last orders 23:00, £15 per person' goes a long way to reducing the restaurants of London into a manageable choice.

Where more information is available, users should be able to go directly to that presentation, and then return directly to the menu to consider the other options. This is usually also the point at which the system can load data into the printer, to provide a list of selected items or cross-referenced material such as a map.

For a published product such as an encyclopedia, retrieval facilities may also include some form of annotation to identify the references of interest, or even to rank these in order of interest. Where one idea leads to another, the system should also allow users to leave bookmarks to retrace the journey and pursue other lines of enquiry.

Retrieval systems should be as flexible as possible, without overwhelming the user with choices. This is one of several points at which field testing with typical users can be invaluable – not the least because this is also one of the points where the production team must accept that the target audience may apply values, criteria and logical processes which confound the perceptions of content providers, designers and programmers. Designers and content experts may fulminate, but effective programmes must primarily satisfy their users' needs and expectations. A well-designed programme may also suggest new ways of thinking and working, but only after users are engaged and open to suggestions.

Administrative software

Administrative software is now used mainly in training, education and marketing, but a modified form of record-keeping can also be attractive to consumers. Some

adventure games, for example, allow players to quit and resume a long adventure without having to start from square one every time – which is, after all, more like real life than a game that obliges users always to start again from the same place, but allows them to play each new round with the benefit of hindsight.

In professional applications, administrative software can provide many services, some of which can also be offered in consumer applications. The extra processing power of an 'extended' delivery system may be required to provide all these functions, but it would not be unusual to expect that a professional training facility could:

- Establish and maintain unique records for every user.
- Establish secure sign-on and sign-off procedures which ensure confidentiality (possibly at different levels of access for managers and trainees, for example, or adults and children).
- Assist in recording the progress of every user through the programme, course or game.
- Manage exploration and learning by maintaining and displaying records of progress, suggesting routes, assigning lessons or exercises, or supplying reading lists or sources of further information.
- Administer tests and exercises (usually, with a degree of randomization to discourage cheating).
- Provide feedback on performance and progress.
- Maintain practical records which succinctly analyse individual and collective performance in a way that managers, instructors or parents can easily apprehend, and transfer these to other programs (such as reports to students or their managers) for analysis or evaluation.

CD-I packages such as *Caesar's World of Gambling* keep a record of players' scores even if the system is switched off between games; CDTV's *Dr. Wellman* allows users to restrict access to 'adult health' topics with a password which those in control can easily change.

Meeting special needs

Multimedia systems are perhaps the first form of communication which can easily address a range of special needs in a single package. CD-I has inherited two particularly striking features from its immediate predecessors, in its ability to offer quantities of speech-quality sound and volumes of text databases economically within the disc's

storage and processing capacities – and to provide users with a variety of functions to manipulate these to suit themselves.

The arguments for meeting special needs are not entirely altruistic, for a significant percentage of the population would benefit from the enhancements that CD-I could easily provide in products for the consumer market and professional applications. In conventional media, the cost of producing special editions is often prohibitive, but the creative application of CD-I technology could address this market with products of unprecedented value to their users, at relatively little additional cost to publishers.

In 1980, Britain's Independent Broadcasting Authority estimated that 8 per cent of the population cannot understand television dialogue properly.[10] The Institute of Hearing Research reckons that 17 per cent of the adult population of Great Britain – some 7.5m people – suffer some degree of hearing loss. Age, of course, is a factor, but amongst those under 16, at least six per 1000 (some 60 000 British children) have significant hearing difficulties.

Surely, any audience that represents up to 17 per cent of the total population is worth addressing. The critical argument is to remember that most people with special needs are not profoundly disabled, but simply face challenges from conventional broadcast media which systems such as CD-I could address. People who can follow face-to-face communication or cinema films may still have difficulty with television and video – which so often separate sound and pictures and so rarely provide subtitles or signing – or with the small and inflexible display on a TV screen or monitor.

The facilities which make programmes accessible to special audiences often appeal to other users. Most people benefit from hearing unfamiliar words pronounced while seeing them spelled, and to read and hear simultaneously helps us to understand and retain new information better. Those who are not fluent in the language of the programme often benefit from sub-titling, while many of the functionally illiterate may find text easier to follow with the assistance of a spoken commentary. Services for the hard of hearing, or those who want optional text facilities, include:

- *Constant access to subtitles which accurately reproduce (rather than paraphrase) all the words spoken in the programme.* The Royal National Institute for the Deaf (RNID) recommend that 'regional dialects are retained'; equally, noting the incidence of sound effects and music is also important in conveying the effect of a programme to all its viewers. Much of the television material best suited to multimedia publishing already includes subtitles, as broadcast services in many countries are now obliged by law to provide subtitling in a certain percentage of programmes and/or in areas such as news, public affairs and documentaries.

- *Supplying the script of the programme as a series of audio-visual essays, illustrated by windows of still and moving images from the main body of the programme, or with a toggle to move between the visuals and the complementary text.* Video windows can hold the first frame of the sequence as a still until the user sets the picture in motion. Colour-coding can identify exactly the text which accompanies each video clip or picture, or describe associated sound effects.
- *Providing options to turn off background music or ambient sound so that hearers can concentrate on the spoken commentary.* For many with a mild hearing loss, this is enough to make broadcast dialogue comprehensible. The option to mask the image plane behind a talking head also assists lip-readers by reducing visual distraction. (Quite a few television viewers would probably appreciate some of these options, to make their own decisions about the use of incidental music or laugh tracks.) CD-I, which stores and processes these components separately, can easily provide options as yet impracticable in broadcast television or video.
- *Providing signing (typically, in a window which always appears in the same screen position) in any programme of special interest to the deaf and hard of hearing.* The visual conventions for signed interpretation, including advice on formats and colour schemes, are available from the appropriate national institutions and broadcasting councils.

The extensive use of computers to assist the visually-impaired means that there is already a range of guidelines, software and hardware products to enhance screen displays to meet different needs. Facilities here could include:

- *A choice of large screen fonts and colour combinations, which viewers could use to display ordinary text screens or the optional facilities described above.* The computer unit at the Royal National Institute for the Blind (RNIB) find that taste and ability both determine any one person's choice of display systems. Scrolling text up and down the screen makes larger fonts easily accessible, and the option to reverse the image (to see white out of black, for instance) can also make text and graphics more accessible for some types of impairment.
- *Optional audio commentary for all the visual presentations on the screen – including titles, captions and text labels on icons, for the benefit of those who can follow the flow of the programme but simply cannot read ordinary screen text.* As an option, this may mean that users simply activate a hotspot (an icon, or a title, for example) to hear a brief audio prompt – a facility, again, which many users would appreciate simply as an optional help function.

For those who cannot easily manipulate standard remote control units or keyboards, a great deal of work has been done in computing to design more versatile control devices, and these products can be incorporated into a multimedia delivery system like any other optional peripheral device.

Technology aside, it is important too that all designers and scriptwriters think seriously about the portrayal of people with special needs in their programmes, to provide images which are not exploitative or patronizing, but simply realistic. It is also worth considering that people with special needs may also have developed, through education and experience, conceptual and creative skills which are well adapted to the design of effective multimedia communication, and can make significant contributions to a well-rounded production team. Users with special needs can provide practical advice during the design of the programme, and during the frequent cold tests which determine how typical users respond to specific content and features while there is still time for amendments and improvements.

The social argument here is incalculable, for we have never had consumer products which provide facilities for special needs as a matter of course, and give people with special needs the same access to entertainment and information as the market at large. Fortunately, the commercial argument is also sound, and national institutions and councils can do much to assist publishers and programme-makers with advice, research and contacts. Hardware and software tools, design standards and practices, all exist in this niche market – multimedia producers have only to add these tools to their platforms to make a significant enhancement to their own range of products and services.

SOME ADVICE FROM THE FIELD

The experience of designers and publishers in computing, interactive video, print and corporate video, also suggest criteria for identifying appropriate subjects and treatments for CD-I, and principles for good programme-design.

Judging criteria

Designers may find interesting models for interactive multimedia programmes in the judging criteria of awards competitions. Multimedia systems, in their variety and complexity, are a judging committee's nightmare, but this at least obliges the

organizers to set out evaluation criteria. The need to supply a discrete delivery system for virtually every entry has also made interactive video competitions expensive and difficult to organize. Streamlined systems such as CD-I should allow entrants simply to submit software and supporting documentation, in the manner familiar to entrants in video and film competitions.

There are a few competitions exclusively for interactive video and multimedia, but most awards for interactive video or multimedia are given within corporate video or training competitions. The American Cindy Awards Showcase for Corporate Video specified nine key points in their criteria for judging interactive programmes:[11]

1. Achievement of overall objectives (considering the type of application, its intended audience, and subject matter).
2. Creative approach (particularly, fresh and imaginative presentation methods).
3. Video direction (specifically, a smooth and purposeful flow to the action).
4. Technical quality (specifically, of video features such as photography and editing).
5. Interactive design (including menu structure and indexes, navigational controls, levels of information available, and help and feedback routines).
6. Interactive program execution (including speed and accuracy of responses, complexity and transparency of design, use of windows and graphics, and of output devices and system utilities to provide additional features both for end-users and those managing or providing the system).
7. Writing (including captions, questions and instructions as well as the main body of the content, dramatic or factual).
8. Graphics (both technical and artistic quality, and relevance to their context).
9. Subjective evaluation – the key point in any one person's perception of a creative achievement, and a criterion overlooked in many official score cards.

Competitions, of course, often reward innovation and creativity without reference to achievement – necessarily so, when judges lack the means and time to conduct such evaluations. Thus, much award-winning work fails to perform commercially, while that which is successful in the field rarely makes the short-list in a competition for showpieces. This trend is not unobserved, and some competitions (such as that of the British Interactive Multimedia Association) now include a prize for achievement, which may be awarded well after a programme's first release.

Interactive games and information systems

With the emergence of consumer products such as CDTV and CD-I, developers from other markets began to recognize a wealth of talent in the computer games industry, among people who clearly understood a great deal about engaging and sustaining users' interest, and applying interactivity in creative and intellectually satisfying ways. For example, at Intertainment, the Annual Conference on Interactive Entertainment, in New York in 1989:

- Douglas Crockford from LucasFilm's Game Division identified features which he thinks new systems must provide to surpass the current generation of consumer entertainment products: more intrinsic value, the ability to tell a good story, genuine interaction, more computer power, faster reaction times than CD-ROM, and higher resolution (i.e. better picture quality). 'Story is important,' he said, 'So don't mess it up by changing outcomes'.
- John Perkins of Perkins Engineering, who worked on interactive games for Hasbro, also emphasized the importance of continuity and logic. 'Don't make the player feel stupid,' he said. (His view of the quest for moving pictures was, 'full motion, full screen or nothing'.)
- Jim Reilly of Touch TV said: 'You must look for contiguous interaction that appears to be linear. The goal is to create a formula that allows a person to naturally interact with a show without being self-conscious.'
- Seth Meyers of the Children's Television Workshop added: 'Passive watching is OK for TV, but as soon as you give a child control, they want to do things'.

The computer games market reflects trends in home entertainment; public information systems offer another perspective on new media in the community:

- Jane Whittaker, Arts Marketing Officer at Cartwright Hall in Bradford, Yorkshire, observed that, while the interactive terminal in the museum's entrance hall has been a great success with all visitors, some adults will take the information from the system, and then ask the same questions again of a museum attendant, for the reassurance of human contact. She, like many observers, also notes that children are eager to explore new machines, while adults are often hesitant.
- Tony Blake, of Intersearch Systems, developed an information terminal for garden centres and do-it-yourself outlets. He observed that adults were often drawn to the system by their children. The children were attracted by the novelty of the system, the adults by the information they found there. Children's attention often wandered when the novelty wore off, just as the adults began to engage with

the contents of the programme, and thus to gain the interest and confidence to proceed on their own.

- Peter Lewis, Director of the British Golf Museum, says 'When confronted with the first touchscreen, visitors are often shy and tentative, but by the time they get to the fourth one, wild horses can't drag them away'.[12]

The challenge is to provide systems which invite interaction, and reward exploration – and do not leave users alone at home wishing for the support of an attendant or tutor.

Two dozen words

In the hundreds of thousands of words already devoted to interactive systems, a handful seem to recur. The ideal interactive multimedia presentation would be:

- accessible
- appropriate
- attractive
- challenging
- concise
- consistent
- effective
- engaging
- flexible
- helpful
- intuitive
- logical
- non-judgemental
- persuasive
- polite
- realistic
- relevant
- responsive
- sensitive
- stimulating
- unambiguous
- unpatronizing
- useful
- worthwhile

Any programme which achieves a good percentage of these should be well on the road to success. Of course, this list does not include words like 'fast' or 'cheap', but a project which works on other levels is more likely to be cost-effective than one which is designed primarily to meet constraints of time or resources.

Notes

1 John Ramo, Sonic Images, speaking at the Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.

2 Philip Mittelman, CD-I Systems, speaking at the First Multimedia Conference on Interactive CD, London, 18–19 June 1990; sponsored by Philips, Sony, PolyGram and Matsushita.
3 Jerry Lundquist, Interlight Productions, speaking at the Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.
4 Theo Wright, 'Following the Yellow Brick Road – Some Observations on Multimedia Databases', unpublished draft paper, 1990.
5 Peter Lewis, British Golf Museum, speaking at Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.
6 Drs. Jean-pierre Isbouts, The ArtSpace Group, Philips Interactive Media of America (PIMA), speaking at the Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.
7 Cherrill Smith, Stratos, speaking at the First European Conference on Multimedia and CD-ROM, Wiesbaden, 9-11 September 1991.
8 Jay Samit, Comparing Motivational and Traditional Approaches to Interactive Videodisc Instructional Design at Ford Motor Company, *The Videodisc Monitor*, September 1990.
9 Gabriel Ofeish, Howard University, speaking at Comdex & Windows World 1991, Atlanta, 20-23 May 1991.
10 Channels to Access, a paper prepared and distributed by the Royal National Institute for the Deaf (RNID) and Deaf Broadcasting Council (DBC); available from the RNID, 105 Gower Street, London WC1 6AH; DBC, 592 Kenilworth Road, Balsall Common, Coventry CV7 7DQ.
11 Sandra Helsel, Cindy Interactive Video Competition, *The Videodisc Monitor*, February 1990.
12 Peter Lewis, British Golf Museum, speaking at the Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.

6

CD-I discs and drives

This chapter provides a description of the physical structure of a CD-I disc, the CD-I delivery system and CD-RTOS real-time operating system. It also explains how hardware and software affect the ways in which the various compact disc platforms – including CD-DA, CD-ROM, CD-ROM XA, CDTV, Photo CD and DVI technology – handle multimedia presentations.

THE GREEN BOOK

The complete CD-I specification is known as the *Green Book*. CD-I's *Green Book* complements CD-DA's *Red Book*, CD-ROM's *Yellow Book* (which includes XA's extended architecture) and the *Orange Book* of recordable compact discs such as Photo CD. These names reflect a convention established in America for another set of documents altogether, but the rainbow of CD specifications shares nothing but nomenclature with these or various other colour-coded titles.

The complete CD-I *Green Book* was originally available only to organizations which had full licences from CD-I manufacturers to develop CD-I applications. However, in the autumn of 1990, Philips elected to make the *Green Book* available to all developers and publishers with an interest in CD-I, so all designers should now work directly to the specifications in the *Green Book*. This chapter offers an overview, to which the *Green Book* adds essential detail.

One important fact to remember here is that CD-I offers a choice of three audio encoding methods (each in a choice of stereo or mono), and four basic graphics encoding formats (some of which also provide various levels of quality). These are all explained in more detail in the next chapter; at this stage, suffice to note that:

- CD-DA employs the extremely high fidelity of Pulse Code Modulation (PCM), which occupies the full bandwidth – that is, the whole of the data channel, leaving no room for other information. CD-I (and CD-ROM XA) use a modification of this system, called Adaptive Differential PCM (ADPCM), which offers three levels of fidelity – A, B and C – and occupies proportionately less storage and processing capacity as the quality is reduced.
- Computer graphics variously employ some form the RGB encoding, which assigns a finite number of colours or hues to each of three primary colour groups (red, green and blue). High-quality graphics assign eight bits per level (that is, 256 discrete hues – or 2^8 – for each of the three colours, or 16 777 216 hues altogether). CD-I employs four encoding methods – DYUV, RGB 5:5:5, CLUT and RLE – which, at various levels, can employ anything from 7 to 16 777 216 colours in a single image.

Explanations at this level are necessarily cyclical: it helps to understand something of the disc's structure before approaching its encoding techniques, but it helps to understand the capacities of the various audio-visual formats to appreciate the technical constraints which define them. The more detailed aspects of encoding CD-I's DYUV, RGB 5:5:5, CLUT and RLE formats are discussed in the next chapter.

DATA ORGANIZATION AND STREAMING

This chapter primarily addresses CD-I discs and drives, but includes comparisons to other compact disc platforms – audio on CD-DA, data files on CD-ROM, multimedia on CD-ROM XA and CDTV, and digitized photographs on Photo CD, as well as some aspects of DVI technology – all of which are explained initially in Chapter 2, Multimedia Platforms.

The efficiency with which any one platform performs as a multimedia delivery system depends both on the organization of data on the disc, and the way in which information is retrieved and processed. This is calculated as:

- The 'seek time' needed to find data on the disc, position the reading head within the drive or player, and begin the data transfer.
- The actual transfer rate at which data can be sent from the disc for processing.

Systems such as CD-ROM and CD-I employ fast drives, which move the reading head radially across the disc from one pick-up point to another. Once in position, the head

then waits for the disc to rotate to the point at which the desired data begin, and starts to read. As Appendix 2 explains, this happens fractionally sooner near the start of the recording (at the centre of the disc, where velocity is nearly 500 rpm) than at the end (on the outer edge, where the speed has slowed to nearly 200 rpm).

- A typical rotation takes about 0.12 seconds (120ms) at the centre of the disc, and about 0.28 seconds (280ms) at the end.
- Experiments in Philips Research Laboratory, with CD-ROM discs, revealed that typical seek times vary from about 0.3 seconds (300ms) between data in adjacent locations and 0.6 seconds (600ms) over long distances.

Thus, seek times depend on where and how data are stored – finding a new file takes longer than finding data within the same file, for example. Their actual position on the disc (whether near the centre or near the edge) is less important than the length of the journey between any two given locations.

Some form of traffic control is required to keep information flowing smoothly from the disc through the appropriate processor(s) to the output device(s).

- Data are sometimes held in temporary storage banks called buffers which act as a kind of waiting room for information in transit between the disc and the processor.
- Alternatively, data can be streamed – that is, transferred from the disc to the processor at just the right speed to travel through the system smoothly and without pauses.

The magnetic disks which hold conventional computer data can usually supply information faster than the computer can process it. Thus, multimedia systems which employ DVI technology and fast hard disks may suffer from 'fragmentation' when data pour off the disk so quickly that they are effectively scattered in many small pockets of memory as the system struggles to process them. This obliges the reading head to seek more often and, thus, less efficiently. Intel provide a utility program to address this problem with DVI and hard disks; so long as data are stored in the correct order on compact disc formats such as CD-ROM or CD-I, fragmentation does not occur in these platforms.

Compact discs, for all their advantages, are slower than magnetic media, and thus well suited to streaming rather than buffering most data. This in turn means that systems such as CD-I can employ processors which are slower, and cheaper, than those designed for professional data processing environments.

For multimedia systems, interleaving and synchronization are also important, to ensure that all the disparate elements in any one presentation are processed and displayed in the right sequence, at the right time. Lip-synching the audio and video for a talking head, for example, is a challenge in audio-visual media of all kinds. Various codes, and time codes, identify data and synchronize the individual elements in a multimedia presentation.

To stream data at the correct rate, it is sometimes necessary to add blank sectors (such as 'silent audio') to effect minute adjustments to the data flow. This padding of course adds to the ultimate size of a data file, but arranging data efficiently to interleave information of different kinds can minimize redundancy.

CD MODES AND FORMS

CD-ROM established conventions for data storage on compact disc which CD-ROM XA and CD-I also employ. Data on compact discs can be recorded in two modes, one of which in turn contains two forms, to provide a range of data error detection and correction codes for information of different kinds. The choice between modes and forms lies between more protection or faster processing.

- Mode 1 always contains a higher level of data error detection and correction codes than Mode 2, and is designed for data which are sensitive to small errors. CD-ROM, DVI technology and CDTV all employ Mode 1.
- Mode 2 is designed for data such as audio and video signals, which need to be interleaved, sector by sector, to effect a smooth flow of audio-visual information, but which are not so sensitive to errors as computer signals: CD-I and CD-ROM XA always employ Mode 2.
- Mode 2 contains two forms. Form 1 contains the same data error detection and correction codes as Mode 1, but even Form 2 data are vetted during processing, so errors such as a misplaced pixel or line of video data can be concealed before the information reaches the delivery system.

Photo CD always employs Mode 2, Form 1. CD-I employs both, setting the greater protection of Form 1 against the faster processing of Form 2. Audio and video data are always recorded in Mode 2, Form 2; program-related data (that is, run-time text, indexes, hotspots, navigation and other data which are not specifically audio, video or program code) are recorded in Mode 2, Form 1.

- Form 1 data are typically transferred at a rate of 150KB per second, Form 2 at 170.2KB per second. (CD-DA audio moves slightly faster, at 171.1KB.)
- All data recorded in Mode 1 or Mode 2, Form 1 (that is, with extra error protection) must pass through the system's central processor. Data in Mode 2, Form 2 can be sent directly to the appropriate output channels.

Thus, the choice of Mode 1 or Mode 2 (and, within Mode 2, of Form 1 or Form 2) determines how quickly and easily data can be transferred and interleaved. CD-ROM XA with Mode 2, for example, sends audio data encoded in the ADPCM format directly to the audio processor, where CD-ROM with Mode 1 has to send all data through the central processing unit first. This is one of the ways in which XA's extended architecture addresses the needs of multimedia systems.

Both DVI and CDTV systems, which also employ Mode 1, use buffers to interleave audio and video. DVI technology demands a powerful processor, assisted by micro-coded chips on the ActionMedia interface board; CDTV, as a consumer product, employs a less powerful processor, together with a few clever techniques and some limitations on its handling of interleaved data. CD-I and CD-ROM XA employ Mode 2, which provides superior data interleaving and de-interleaving with fewer demands on the main processor than Mode 1. In a nutshell, real time transition of audio and video data – the essence of multimedia – is easier with Mode 2.

Error detection and correction

Data errors in computing are similar to typing errors in printed matter. Sometimes, the meaning of the message is clear even if one or two letters are wrong or transposed. Occasionally, the meaning of the message is garbled or distorted in unexpected ways. (At a British computer show, one interactive video company was dismayed to check their entry in the exhibition catalogue to find that their large range of competitively-priced software was described not as 'extensive', but 'expensive'.)

The software programs which check spelling in word processors do not identify 'literals' – words which are correctly spelt, but inappropriate. At least the sense of a word is often apparent from its context: numerical data, or coded information, are more difficult to interpret comparatively. It is tricky enough to identify the mistake in a complex equation, but where numbers stand alone, there may be no clue to indicate that '1000' is a mistake for '100', or '189' for '819'.

Of course, many compression techniques deliberately shed superfluous data, to the point of dropping whole fields and frames in a video signal. Where errors occur, the

effect is often no more than this – to lose a snippet of datum, rarely equivalent to more than a field of video or a sample of audio.

CD-ROM and CD-I employ three levels of code to detect and correct data – Error Detection Code (EDC), Error Correction Code (ECC) and Cross-Interleaved Reed-Solomon Code (CIRC). This represents an average bit error rate of one bit in 10^{18}. Conversely, a CD disc could theoretically sustain a hole 2.5cm in diameter, and still be read accurately with CIRC error correction codes.[1]

CD DATA TRANSFER CHANNELS

Interleaving and synchronization are facilitated by the 32 separate data channels within the CD-I system: 16 can be used for data of any kind, including audio, and 16 for any data except audio.

These channels sometimes work like those of a television set, which can receive many broadcast signals, and jump instantaneously from one to another, but which usually displays only one channel at a time. But there are important differences: most televisions present one pair of synchronized audio and video signals at a time (or, in some models, sound and vision for one channel, with windows to monitor the picture on one or more others); equally, the television is always receiving all the signals currently being broadcast to it – most of which effectively go to waste as they are not wanted.

The CD-I system must be more selective, and offer only the choices which users are likely to want at any one time. All the signals which pass through the system consume finite storage space and processing power, so it is wasteful to deploy more than are needed at any one time. Mode 2 supports the various use of multiple channels, but both CD-I and CD-ROM XA systems include hardware to ensure that the channels are always being used efficiently, to minimize demands on the main processor.

When a choice is desired, CD-I may employ several audio channels simultaneously to offer, say, complementary soundtracks in a language training programme, so users can switch instantly from one to another. At other times, the efficient use of all the available data channels supports the steady flow of disparate information to the multimedia presentation. The 32 channels can be deployed in any combination from none to all – a potential 4 294 967 266 variations. An instruction called a channel selection mask identifies the channel or set of channels to be used at any one time. This mask, in turn, can be changed from one record to another, so the potential combination of data channels over the course of a whole presentation can be very high indeed.

CD TRACKS AND SECTORS

The smallest unit of recorded datum on a compact disc is called a frame (in CD-DA) or a sector (in multimedia platforms such as CD-I).

- A sector (or frame) is the smallest block of discrete information on a CD, with total length of 2352 bytes (2.35KB).
- The data in any one Mode 2 sector can only be of one type (e.g. video, audio or program-related), but a series of sectors in a stream can contain data of all kinds, to ensure a constant flow of information of different types to the various parts of the delivery system.
- CD-I systems process data at a uniform rate of 75 sectors per second, or 0.013 seconds (13 milliseconds) per sector. This represents a flow rate per second from 150KB (Form 1) to 170KB (Form 2), allowing for the variations described above.

All the information in any one application is held in a single track, in much the same way as individual music tracks are stored on an LP record.

- CD can hold from 1 to 99 tracks, which can vary in length from 300 sectors (i.e. about four seconds' worth) to the total recordable surface of the disc.
- Any one track can contain any combination of data which the specific CD format supports – data, text, music, still and moving pictures, and computer programs.

A classical music recording may store a concerto in one long track, while a pop record offers a dozen or more individual tracks of various lengths. A CD-I recording, similarly, may employ a few large records, or several small ones.

CD STRUCTURE

Compact discs are not unlike the familiar model of the black vinyl LP, although the structure of the record is plain to see, and the CD offers only an enigmatic reflective surface. Still, both essentially contain:

- A lead-in area (in CD, Track 0, which contains the CD's table of contents).
- A program area, which holds all the data in the presentation as one or more discrete tracks.
- A lead-out area (called, in CD-I, Track $AA) which identifies the end of the recorded material on the disc.

CD-DA frames and sub-channels

A CD-DA disc comprises 75 frames (i.e. sectors) of audio data, plus eight sub-code channels, labelled P to W.

- The first of these CD-DA sub-channels (P) carries the music flag to indicate if there is music; this marks the end of each individual track, to facilitate track skipping through a recording.
- The second CD-DA sub-channel (Q) carries most of the information about the data on the disc. It defines whether the disc contains CD-DA or CD-ROM data, provides a table of contents, and indicates running times for each track and for the disc as a whole. It also includes an error detection routine called cyclic redundancy check (CRC).
- The *Red Book* does not assign specific functions to the remaining six CD-DA sub-channels (R, S, T, U, V, W), so these can be used variously for text or graphics, to support CD+G applications; however, there are specifications to guide developers in the use of these sub-channels.

Channel Q may also include a catalogue number, and information about individual music tracks on the disc – serial number, year of issue, owner and country of origin – using the music industry's International Standard Recording Code (ISRC).

CD-I Track 1

The first track on a CD-I (see Fig. 6.1) disc must always be arranged in order to provide:

- A set of 166 message sectors, which specifically address the use of a CD-I disc in a CD-DA player (i.e. to hear audio tracks alone), by asking users to adjust the volume to anticipate the CD-DA player's more powerful audio output.
- A disc label, compatible with ISO 9660, which describes all the files on the disc, its contents, size and creator, as well as any computer software which may be recorded there.
- A set of 2250 message sectors.
- CD-I data, which may fill the balance of the disc with a single application program.

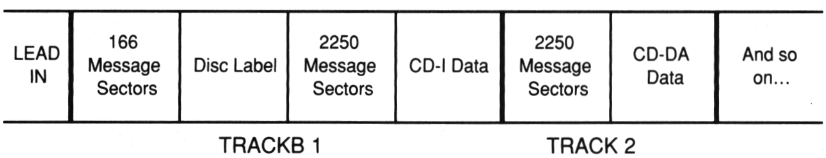


Figure 6.1: First tracks on the CD-I disc

If there are any CD-DA tracks on the CD-I disc, the very first track must be arranged as described here, and must contain CD-I data. However, the CD-DA tracks can only be recorded after the last of the CD-I tracks, and there must be a set of at least 2250 message sectors (30 seconds' worth) between the end of the CD-I portion of the disc, and the beginning of the CD-DA recording.

CD-I disc label

The disc label comprises three standard records which establish the location and description of essential structural information on the disc:

- The File Structure Volume Descriptor, which describes the structure of all the files on the disc.
- An optional Boot Record, which specifies the location of the Boot File, where data from a disc rather than the player's own memory is used to prepare the delivery system.
- The Terminator Record, which marks the end of the Disc Label for the player seeking information there.

As these are all sensitive computer data, the disc label must be in Mode 2, Form 1, to detect and correct errors.

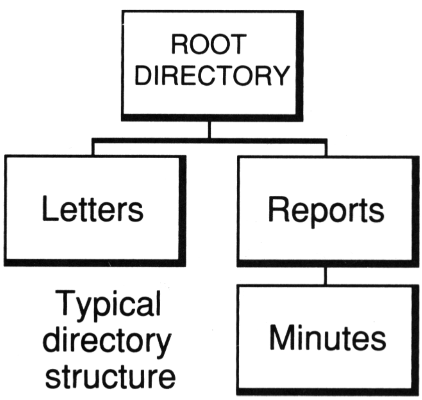
Files, directories and paths

The disc label also contains a path table, which defines the directory structure and lists the files on the disc. All CD-I data are held in files, which are arranged within directories. This relates back to universal practice in computing environments, which is based in turn on a metaphor derived from conventional paper-based office systems, in which papers are gathered in files, files in folders, folders in drawers, drawers in cabinets. Computer data are held in files, files in sub-directories, sub-directories in directories.

- Related data are held together in a file; related files are kept together in a directory. Directories are arranged hierarchically, from a single starting point which is called the root directory.
- When one directory is placed inside another, the one 'inside' becomes a sub-directory of the directory above it in the hierarchy. CD-I's operating system can arrange sub-directories of any size to any depth.

- Within each directory, each of the files it contains is identified by a File Descriptor Record, which specifies the file name, number, size, address, owner, attributes, interleave instructions and access permissions for read.
- Each directory has a unique name and location number. Location numbers are assigned sequentially from the top down, and from left to right across each register of the hierarchical path.
- The point-to-point journey from the root directory through various directories and sub-directories to any one in particular (and thence to the files which it contains) is called the path, and the record which logs all this information is called the path table.
- The path table provides an index of all the directories on the disc, with the name of each directory file, its relative position (the number unique to every directory), and the number of the 'parent' directory immediately above it (which, of course, may be shared with other sub-directories in that part of the hierarchical structure).

Written as prose (for example, in instructions to the computer, or documentation), path names always start at the top and identify every directory in the path, in order, with a standard character separating each name: CD-I employs the familiar slash or oblique (e.g. Root/Reports/Minutes). Figure 6.2 illustrates this structure.



Path Table

Relative Position	Parent Directory Number	Directory File Name
1	1	Root
2	1	Letters
3	1	Reports
4	3	Minutes

Figure 6.2: Typical directory structure and path table

Names are chosen rather than assigned (often, by the person who creates the file or directory, according to highly personal criteria). There is always a finite length to the name, which can be long enough to employ whole phrases in some computer systems, but must be reduced to a short word or acronym in others. (MS-DOS, for example,

typically dictates a pattern of eight characters for the file name, a full stop, and three more to indicate the file type, e.g. 'filename.lib'.)

Names ought, as far as possible, to use simple words or obvious abbreviations which indicate something unique about the contents of each file and directory; naming conventions are one aspect of standard practice which every project must seriously address at the outset, or risk losing valuable information in obscurely or wrongly named records. CD-I files can be of three types:

- Standard computer data files, typically employing international standards such as Interchange File Format (IFF) and various standard computer graphics file formats (such as RGB and PICT).
- Directory files, which co-ordinate the structure of the data in the program.
- Real-time files, which deliver audio-visual information to the system on demand, in a carefully-modulated stream. (Real-time records are explained more fully below).

The project team must agree on standards for file management, to ensure good working practice and the efficient use of the resources within the CD-I disc and player. Files can be interleaved like any other data, and one can begin before another ends; however, seeking and opening different files is a time-consuming task within any one application.

The actual arrangement of data into files and directories will vary according to the demands of the project and local practice within the production team. Laura Buddine of TigerMedia, discussing the design of CDTV games, recommends that all the data for any one scene in a programme be kept as a single file.[2] New Media's Technical Director, Dr. Graham Sharpless, says, 'The number of files should be kept to a minimum to avoid the need to open files – ideally, use a few big files and open them all at the start of the application'.

CD-I SECTORS

The 2352 bytes of a CD-I sector always contain a header, sub-header and data. In Mode 2, Form 1, the sector includes extra error detection and correction code (see Fig. 6.3).

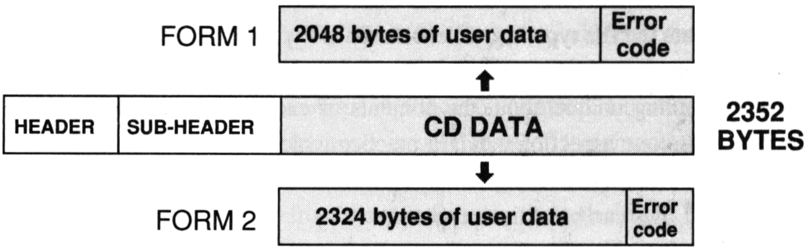


Figure 6.3: Form 1 and Form 2

A header in any CD format always comprises eight bytes of data which record:

- The sector's address (in terms of minutes, seconds and sectors) in relation to the start of the track.
- The form and mode in which the data in that sector are recorded (CD-I data, of course, are always recorded in Mode 2).
- For Mode 2 only, there is also information to assist in de-interleaving data (for example, to sort out four parallel audio tracks, and send each one to a different audio channel).

A sub-header comprises a further 12 bytes of data which record:

- The data type (e.g. audio, video or program-related).
- Coding information (e.g. Level A audio or CLUT 7 video).
- The file number for interleaved files.
- The channel number (i.e. 0 to 15 for audio, 0 to 31 for other data).
- A flag to indicate the form and whether the data comprise a real-time or non-real-time file.
- Flags which signal the end of real-time files or records (end-of-file bits and end-of-record bits, respectively) and time-coded trigger bits which synchronize data in the sector with the program as a whole (for example, to ensure that the images in a photo-essay are dispatched at the correct intervals).

Altogether, this comprises 28 bytes of the 2352 in each CD-I sector. Form 2, with less error protection than Form 1, devotes the remaining 2324 bytes to data; Form 1 reserves 276 bytes for the detection and correction of errors, which leaves 2048 for data.

CD-ROM, which always employs Mode 1, similarly has 2048 bytes free for data in any one sector: the CD-ROM sector comprises 12 bytes of synchronization data, a four-byte header, 2048 bytes of data, and 288 bytes in an 'auxiliary data field' for error

detection and correction codes. CD-DA, with less need for error protection, has 2336 bytes to devote to audio data.

CD-I audio sectors

CD-I audio sectors are structured to meet the specific demands of ADPCM audio. The sub-header for audio data records:

- The emphasis (to reduce audible interference such as 'hiss').
- The number of bits per sample (i.e. 8 bits for Level A, 4 bits for Levels B and C).
- The sampling rate (i.e. 37.8kHz for Levels A and B, 18.9kHz for Level C).
- Whether the sector contains mono or stereo sound.

CD-I audio is recorded in real-time Mode 2, Form 2 sectors (real-time because the audio signals must ~~be~~ processed immediately they are wanted within the system; the exception is audio for soundmaps, which are explained in the next chapter). This allows 2324 bytes for data, which are divided into 18 sound groups of 128 bytes each (a total of 2304 bytes, with 20 bytes spare).

Each sound group devotes 16 bytes to describing the sound parameters, and the remaining 112 bytes to actual data. (This includes both range and filter parameters, which are optimized during encoding for each sound group.)

To ensure a steady stream of data through the system, and facilitate efficient retrieval and interleaving, audio sectors are always laid down in strict sequence. The level at which audio is recorded, in stereo or mono, determines the intervals at which audio sectors are recorded. Figure 6.4 illustrates the relative positions of stereo and mono signals in the three CD-I audio formats (and, by way of comparison, CD-DA).

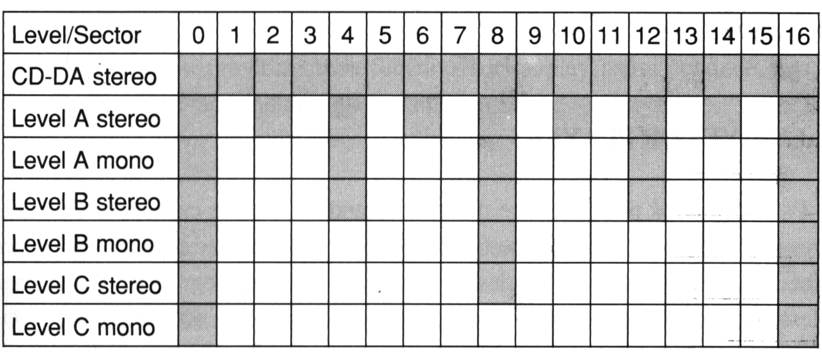


Figure 6.4: Relative sector positions for CD audio

The assignation is rigid: the sectors in any one Level C audio recording, for example, are always arranged at intervals of 16. Of course, with multiple audio tracks, any random group of 16 sectors may contain data for different soundtracks in discrete sectors, each arranged in relation to others in the same audio recording.

For example, with a choice of four languages, all at Level C mono, four out of any group of 16 sectors would be occupied by audio. However, each separate audio track would typically occupy a different audio channel, so the four signals will be de-interleaved, by purpose-built hardware in the central processor, for output to separate channels. Thus, in any group of 16, each of the 4 audio sectors would record data in a different language, for output on a discrete audio channel, and each one would be separated by 15 sectors of other data from the last sector in that particular audio track.

At the same time, if 4 out of every 16 sectors contain audio, only 12 are left for video and other data. This is the foundation of another equation, explained in the next chapter, to determine trade-offs between the quality and quantity of media of different kinds, competing for the finite space in the data channel.

CD-I video sectors

CD-I video sectors are also recorded as real-time Mode 2, Form 2 sectors. The sub-header for video data records:

- The resolution (which may be normal, double or high).
- The encoding methods (RGB 5:5:5, DYUV, CLUT or RLE).
- A ‘flag’ which identifies even and odd lines to facilitate error concealment.

The different demands of the various encoding methods dictate the structure of each sector according to the type of visual material it contains. These are explained in the next chapter.

CD-I DRIVES OR PLAYERS

CD-I’s *Green Book* prescribes the minimum standard, or base case, which all CD-I drives or players must satisfy. The first CD-I developers worked with the .99 version of the industrial-quality player designed specifically for programme-makers and professional applications such as training and marketing. This was succeeded by the 1.0 version, and complemented by the first consumer-quality player, which presaged

the systems which would actually be released commercially on the American market in 1991, and in Europe in 1992.

These first players were modelled closely on the *Green Book's* base case, without undue peripheral features or optional hardware. The growth of the consumer market should see the development of many variations on the base case, as rival manufacturers seek to distinguish their products in a competitive market. These features are most likely to affect the design of input devices (particularly, to add computing's mouse and keyboard to the consumer player's hand-held controller) and provide optional enhancements such as speakers, modems and printers. However, they must meet the base case specifications, so designers can be assured that all the essential features of every model will be the same. Figure 6.5 illustrates the organization of the CD-I base case player.

CD drive and control unit

The CD-I player currently accepts discs in CD-I, CD-DA and Photo CD formats.

- The CD control unit provides random access to all data on the discs, together with a decoder for real-time CD-I files (including ADPCM audio, video, graphics and program-related data).
- The controller reads information from the sub-headers in each sector to identify the type of data in the sector and direct each to the appropriate data channel and processor.
- The controller also uses the information in the sub-headers to de-interleave audio-visual signals and direct the flow of all data through the 16 audio and 16 multi-purpose channels.

The drive control also provides simple functions such as play, pause, continue, stop and eject, familiar from tape and disc players of other kinds.

Audio processing

Audio signals are recorded differently on CD-DA and CD-I discs and, thus, processed differently within the CD-I player. Audio signals from the CD-DA disc (encoded in stereo in the PCM format) travel straight from the disc through the CD-DA decoder and controller to the audio processing unit (APU), and thence to output through the

television, speakers or other devices. Audio signals in the ADPCM format from the CD-I discs (in stereo and mono, at Levels A, B or C) pass through an ADPCM decoder, and thence to the audio processing unit.

- The CD-DA decoder and controller specifically decode 16-bit PCM data of the compact audio disc and send these directly to the audio processing unit. The CD-DA controller also provides high-level error protection for CD-DA and low-level protection for CD-I data.
- The ADPCM decoder decompresses CD-I audio and outputs re-constituted PCM signals to the audio processing unit, whence they are passed (through a special effect processor, if appropriate) to the left and right channels of the television, hi fi, headphones or speakers.
- The audio processing unit acts like a two-channel mixer, which accepts stereo or mono audio signals from up to two sources, through two input channels, and mixes these in various ways for output to two channels (left and right).

The APU can adjust the loudness of each channel separately, to create special effects such as attenuation or panning in real time. This allows any one recording to be manipulated in various ways during the course of the presentation.

Audio passes from the disc through buffers to the audio processor, and thence into the appropriate output device (typically, being divided within the processor for output to the left and right audio channels of a stereo system).

- The buffers are loaded and emptied alternately: Buffer 1 fills and, while it unloads into the audio processor, Buffer 2 fills; while Buffer 2 unloads to the audio processor, Buffer 1 fills again, and so on.
- Both channels of a stereo recording are held in the same sector, and processed together until they are separated within the audio processor itself, which directs them to the appropriate channels of the output device.

Thus, there is effectively no difference between processing stereo and mono. Neither can two mono channels be mixed to create stereo in the base case system.

Random Access Memory (RAM)

Random Access Memory (RAM) provides two temporary storage banks, of 512KB each, which support drawmaps, soundmaps, and special effects in one or two planes. These features – which are described in the next chapter – all rely on holding audio or

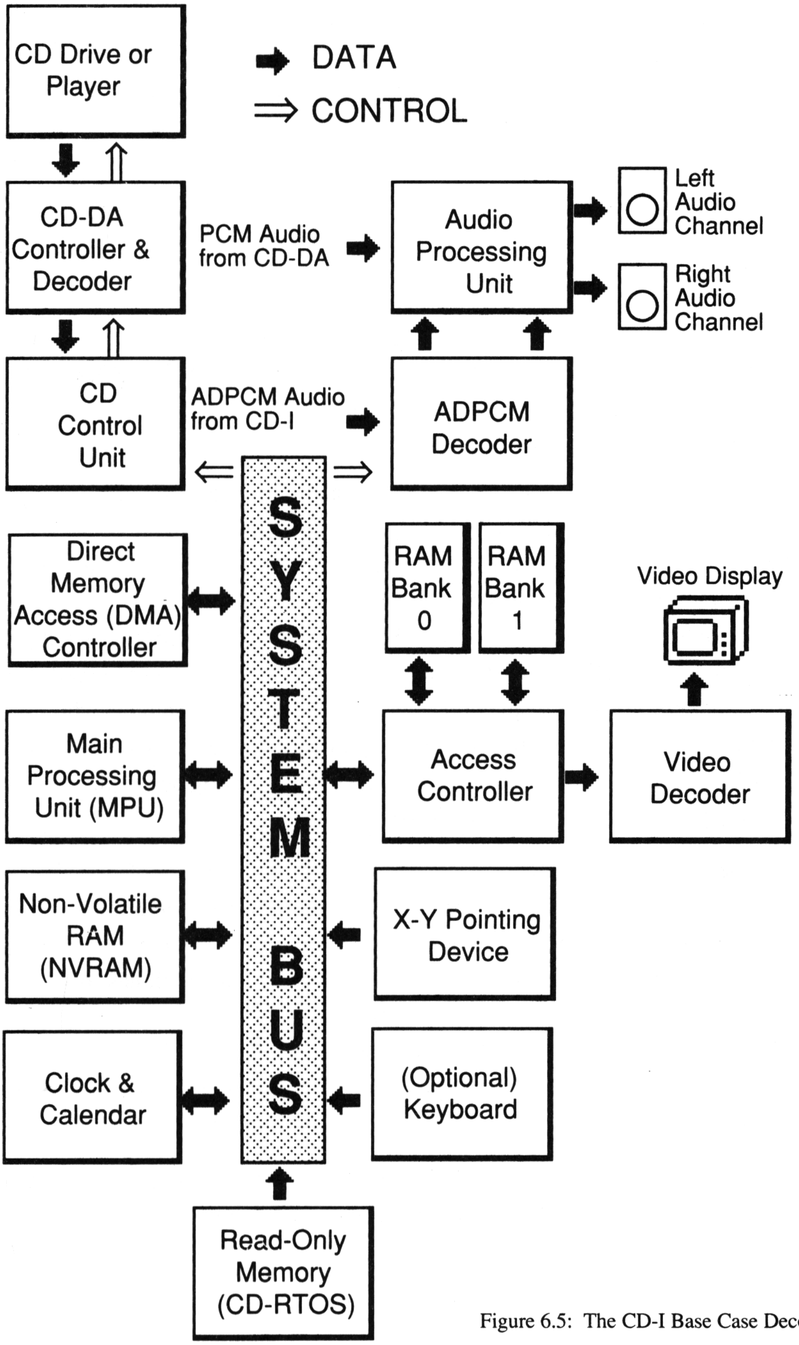


Figure 6.5: The CD-I Base Case Decoder

graphics in memory, to be used in special ways during the presentation, rather than reading them directly from the disc in real time.

Bank 0 is specifically assigned to data for image Plane A, and Bank 1 to data for image Plane B. Thus, data travel along the Path 0 or Path 1, respectively, on entering or leaving the appropriate image bank.

Video processor

The CD-I video processor comprises:

- An access controller, which provides interface between the video decoder, the two banks of random-access memory and the main system bus.
- A video decoder, with two real-time decoders.

Real-time Decoder 0 handles DYUV, CLUT and run-length images; Real-time Decoder 1 handles DYUV, CLUT and run-length and RGB images. (One RGB image occupies both image planes, and fills both memory banks; the other formats occupy only one plane and one bank apiece.)

The output from each decoder can employ up to eight bits for each level of red, green and blue; in practice, DYUV, CLUT and RLE images are usually now decoded with at least six bits per level for display on analogue televisions or monitors while 16-bit RGB 5:5:5 by definition supplies the most significant five bits per level (using the sixteenth bit for transparency – i.e. no colour). As video data are decoded, any special effects are processed in order, as appropriate.

- This begins by identifying transparent and opaque areas in each plane, for colour-keying and the creation of mattes. Pixel repeat is effected within the real-time decoder, separately for each plane.
- The planes are then overlaid or mixed, at which point the brightness of each can be adjusted to allow for effects such as fades.
- Pixel hold is calculated after the two planes have been mixed.
- The backdrop plane and the cursor plane are added last, and the signal is converted to the appropriate analogue signal (PAL, SECAM or NTSC).

The conversion of digital data from CD-I to the analogue display of conventional screens is effected by a Display Control Program (DCP), described below.

Direct Memory Access (DMA)

Direct Memory Access (DMA) can transfer audio-visual and other information directly from the disc to buffers in memory, and thence to the appropriate processor and output device. DMA can also control visual effects and other special features, by moving data within memory. With DMA, data can move around the system without engaging the valuable power of the main processing unit (MPU), which can then concentrate on more demanding jobs.

Non-Volatile Random Access Memory (NVRAM)

Non-Volatile Random Access Memory (NVRAM) provides at least 8KB of permanent memory. This provides information essential to the CD-I system, and offers some storage space for application-specific data such as the scores in a game or bookmarks in a reference work, so that users can turn off the machine whenever they choose, and begin again at exactly the same place, or with a record of past achievement. NVRAM may be supported by a small battery, to protect these data in the event of a power failure.

Other features

Other elements of the base case specification include:

- A microprocessor which, as in any computer-based product, provides the chipset which supports all the data retrieval and processing within the system.
- One or more X-Y pointing devices (such as a mouse, tracker-ball, joystick, lightpen or purpose-built interface device) whose movements are described in absolute or incremental positions, or by velocity of movement. The base case demands that any pointing device must have two trigger buttons, and be able to point at any pixel on the screen in normal resolution.
- A battery-operated clock and calendar keep track of both the time and date, in seconds, minutes, hours, days, months and years (including leap years).
- Read-Only Memory (ROM) which contains the CD-RTOS operating system, described below.

As with most computer-based products, a central system 'bus' or 'signal route' connects all these elements and allows information to pass freely along the appropriate channels between them.

CD-RTOS

The CD-RTOS operating system is unique to CD-I, but it is closely based on a well-known high-performance operating system called OS-9.

All computers are governed by operating systems, sets of programs which define all the rules for bringing data into the computer, processing this information, dispatching it to output devices, and controlling peripheral equipment. Every computer-based system is a universe in miniature, under the absolute authority of its operating system. IBM's Disk Operating System (DOS)™ and Bell Laboratories' UNIX™, for example, are currently two of the most pervasive operating systems in the PC environment. However, many other operating systems exist for other products and purposes, including OS-9 and CD-RTOS.

OS-9 was originally written for Motorola's 6809 micro-processor, in the late seventies, and then adapted to the new high-performance 68000 in 1983. CD-RTOS is effectively an extension of OS-9, which particularly addresses the special requirements of multimedia presentations on delivery systems unlike those conventionally associated with computer-based products. However, the latent power within the system means that a CD-I drive, with a floppy or hard disk drive and keyboard, could function like any other computer based on the 68000 micro-processor and OS-9 operating system.

By extending the power of OS-9, CD-RTOS manages all the data within the CD-I system in real time – that is, as it happens rather than in the artificially elapsed time, or delayed task-scheduling, of many computer systems. CD-RTOS employs a few shortcuts (such as drawmaps and soundmaps), but all data are ultimately delivered on demand, under the direction of the end-user.

To co-ordinate the number and variety of activities which a real-time multimedia presentation demands, CD-RTOS is necessarily also a multi-tasking system which can handle several discrete functions concurrently. In computing, multi-tasking allows a desktop PC to move smoothly between a word processing program and a spreadsheet to compare and even exchange data; in CD-RTOS, multi-tasking controls the seamless presentation of audio, video and program-related data from the disc through the system to the screen and speakers. In technical terms, CD-RTOS has several distinctive characteristics:

- CD-RTOS is a modular multi-tasking operating system, which can handle the multi-level tree structure of the CD-I disc's many directories, and support both random-access and real-time files.

- CD-RTOS is hardware or device-dependent – that is, requires certain specific equipment in the delivery system, to output data to screens and speakers, and respond to input from a pointing device, keyboard or other peripheral.
- CD-RTOS thus also supports the in/out (I/O) processors to handle audio and video output, and input from four data streams on the disc (audio, video, program-related and program code), a pointing device and optional keyboard.
- CD-RTOS also supports arithmetical processors, to handle the large volume of diverse data on a CD-I disc.
- CD-RTOS comprises four main blocks: the kernel, managers, drivers and libraries described below.

CD-RTOS principally affects the creative and functional work of the computer programmer or author, but it is important that the non-technical designer understand the basic features of the environment in which programmers work.

The CD-RTOS kernel

Like other operating systems, CD-RTOS is based on a kernel which represents the heart of the system. The kernel is the lowest layer in any operating system, the foundation on which all other processes rest. The kernel assigns hardware resources to the various processes and functions which the delivery system and the software programs require. The kernel allocates (and de-allocates) the various memory resources to make the best use of available space as the program unfolds.

The kernel also responds to the needs of the delivery system. These may be expressed as systems service requests and I/O calls as data pass from the disc through the various processors and on to the screen, speakers and other parts of the delivery system, in response to instructions from the hand-held controller, mouse or other input device. The kernel itself does not process the data flowing in and out of the system, but assigns these tasks to the appropriate file managers (described below).

CD-RTOS kernel also controls all the aspects of multi-tasking (such as switching between tasks, or suspending one while another is in progress), and responds to interrupts such as spontaneous decisions or reactions from users.

The Configuration Status Descriptor (CSD)

The Configuration Status Descriptor (CSD) provides a 'device status descriptor' for every discrete element in the delivery system. This comprises its type, name, status (i.e.

idle or active) and specific technical parameters. From these descriptions, the kernel can determine the capabilities and capacity of every device from the base case decoder to the optional accessories.

The kernel needs this information to determine, amongst other things, the exact configuration of hardware in any one delivery system – the type of monitor, for example, the destination of audio output (whether to the TV, hi-fi, speakers or headphones) and the potential means of input (whether mouse, keyboard or other optional accessory). Some of these data are stored in Non-Volatile RAM, and some in RAM/ROM; users can supply some of the information to configure the descriptors for optional extensions or peripheral devices (such as a keyboard or joystick).

Initialization

'INIT' controls the start-up procedure, which is similar in all computer-based systems.

- As soon as the power supply begins, the hardware is initialized (that is, given its starting instructions) and the kernel starts to work.
- A start-up screen, greeting or copyright message from the hardware manufacturer is often displayed at this stage.
- If there is a disc in the player, the system may boot up from instructions there.
- Otherwise, the kernel compiles the Configuration Status Descriptor to ascertain the nature and status of every part of the delivery system (rather like a supervisor preparing for the start of a new shift).
- Instructions on each disc initialize the files contained there, with information read from the disc label and path table.
- This leads to a greeting or start-up screen (sometimes by way of the publisher's own copyright message) and the start of the presentation.

This final stage of the procedure is of course repeated if the user inserts a new disc, for the delivery system needs precise information to satisfy the unique requirements of each interactive multimedia programme.

CD-RTOS FILE MANAGERS

CD-RTOS employs three central file managers to control the main activities of the system. The Compact Disc File Manager (CDFM) controls files from the CD-I disc,

the Non-Volatile RAM File Manager (NRFM) controls the player's small permanent memory bank, and the User Communications Manager (UCM) controls audio-visual devices and user interface.

Compact Disc File Manager (CDFM)

The Compact Disc File Manager (CDFM) translates high-level commands from the CD-I disc's program into instructions for the various device drivers which control the flow of information to the delivery system.

The CDFM controls access to the various files on the disc. This includes the protection of data accessible only through a password or code (whether for confidentiality or simply as a commercial device, say, to offer ten games on a single disc, with a separate licensing fee for access to each one). It also includes the scheduling necessary to co-ordinate the many accesses to the disc which multi-tasking requires.

Through the CDFM, data may not be retrieved precisely in the order in which they are initially requested or ultimately displayed, but in the order which makes the most efficient use of available resources (particularly, the movement of the pick-up head back and forth across the disc). With data pouring through the system at the rate of 75 sectors a second, the CDFM can effect minute adjustments to the order in which access requests are processed, to make the system work as efficiently as possible, without impairing the flow of information to the screen and speakers.

There is a special CDFM command to send CD-DA data directly to the CD-DA decoder and controller and provide basic functions common to most CD-DA players (say, to pause, eject the disc, or display the elapsed playing time).

Non-Volatile RAM File Manager (NRFM)

Through the Non-Volatile RAM File Manager (NRFM), the application on a CD-I disc can create its own files within the limited memory resources of the delivery system's Non-Volatile RAM. As the base case calls for only 8KB in NVRAM, in a single directory with no sub-directories, this space must be used efficiently. The File Manager assists with a simplified version of the Random Block File Manager of the OS-9 operating system on which CD-RTOS is based.

User Communications Manager (UCM)

The User Communications Manager (UCM) controls all the audio-visual devices in the system, as well as input devices such as the hand-held controller and optional keyboard.

- The UCM User Interface supports X-Y pointing devices such as the standard hand-held 'thumbstick' controller or optional mouse, joystick or other devices, as well as computer keyboards, which are also optional accessories for CD-I delivery systems.
- The UCM also controls the flow of ADPCM audio signals to the ADPCM decoder. This includes special audio effects (such as attenuation and panning) which are created within the CD-I delivery system itself, as well as audio held as the soundmaps described in Chapter 7, Audio and Video on CD-I.
- The UCM's graphics cursor functions control the size, shape, colour and position of the cursor on the screen.

Other features explained in the next chapter – the two image planes, drawmaps and soundmaps – as well as run-time drawing and text functions, are all controlled by the UCM.

- The UCM allocates and de-allocates memory for drawmaps and soundmaps, in functions called create and close.
- The UCM also moves data between separate drawmaps for effects such as partial-screen updates, scrolling, panning or animation.
- The UCM's graphics drawing functions provide basic run-time drawing and text functions. The drawing functions include line, rectangle, polygon, circle, ellipse, arc and fills, with a choice of patterns, colours and line widths.
- The UCM can define regions in various basic shapes (symmetrical or polygonal) to limit the drawing area within a drawmap, or create mattes for special effects such as those described in the next chapter. The basic shapes can be combined to accommodate irregularly-shaped graphics (for example, to outline and then clip part of an image for display in another drawmap).

The UCM also controls the Display Control Program (DCP), described below.

Display Control Program (DCP)

The Display Control Program (DCP) is defined by the *Green Book* to regulate every field scan on the television or monitor (as explained in Appendix 1), both to manage

the simple display of images on the screen, and produce the special effects described in the next chapter.

- The DCP controls parameters including image encoding methods, transparency, backdrop colour, and the order in which planes appear – A over B, or B over A. For each plane, it defines colour look-up tables, transparent and mask colours, special effects such as mattes and mosaics, and 'image contribution factor' (i.e. the relative intensity or brightness).
- The DCP provides a field control table (FCT) and a line control table (LCT), with instructions for every field, and every line within every field, respectively. As CD-I has two central image planes (A and B), there are separate DCP for each (Path 0 and Path 1 respectively); instructions which affect both planes – such as the order in which they appear – are always held in Path 0.
- The field control table is executed 50 times a second in PAL and SECAM, 60 times a second in NTSC. It holds up to 1024 separate instructions to establish parameters for each field. Variable attributes can also be set here (for example, to determine the order of the two planes at any one time).
- The line control table is executed 625 times a second in PAL/SECAM, or 525 times a second in NTSC, at normal resolution. It provides up to eight discrete instructions per line, and can give separate instructions to each line on screen.
- The DCP supports up to eight matte boundaries on any one line, although one or two can overlap at any one point.

Together, these two assist in the presentation of mattes, borders, scrolling, panning, sub-screens, partial-screen updates and other effects where different instructions must be sent to various parts of the screen.

By specifying the 'display start address' individually for each line, for example, the DCP can hold one part of an image on the screen, and scroll another part. By defining a combination of opaque and transparent mattes in the two image planes, the DCP can hold a still image in one matte on the top plane, and reveal moving video or animation from the second plane, through the transparent mattes (for example, to produce the type of limited animation common in cartoons).

Other CD-I file managers

CD-I can employ other file managers, based on models from the OS-9 operating system, in players extended from the base case system. These include:

- A Network File Manager (NFM), to control a number of CD-I players and, perhaps, OS-9 computers, in a network – for example, in a training centre, public information bureau or department store.
- A Random Block File Manager (RBF), to control files on a mass volume storage device – for example, should the CD-I systems in a network be enhanced by the addition of magnetic hard or floppy disk or RAM disk drives. (The RBF, managing files from other storage media, complements the Compact Disc File Manager, which controls files from the CD-I disc itself.)
- A Sequential Character File Manager (SCF), to control optional peripheral devices such as a printer or modem. (The SCF complements the User Communications Manager, which controls devices in the base case system.)

All these file managers communicate with the equipment in the delivery system or network through the agency of intermediary device drivers, described below.

Drivers

All operating systems employ drivers to control each of the individual peripheral devices in the delivery system. Drivers handle all the low-level functions required to deal directly with the various input and output devices.

A CD-I player, for example, may be linked to any of hundreds of different makes and models of television, and have a choice of several keyboards or joysticks, as various manufacturers begin to supply products to the CD-I market. The device drivers accommodate the differences between various individual products, to effect standard communication between the delivery system, the various file managers, and the data on any one CD-I disc.

To identify the specific equipment in any delivery system, CD-RTOS employs device descriptors, which include the name of the appropriate device driver and file manager (together with such constants as provide essential information about the device). These supply the operating system with the correct address to communicate with the various input and output devices in the system.

Libraries

Most operating systems employ program or software libraries, which provide the program code for basic functions which are frequently performed. These typically include utilities (which execute various useful tasks, such as formatting text or copying

files) and assemblers or compilers (which translate source code from the high-level language in which the application is written, to the low-level assembly language or absolute code which the computer's central processor understands).

CD-RTOS has its own library of essential routines, including the mathematical calculations needed to handle data of various types, I/O functions, and synchronization. Developers can also employ proprietary software libraries of functions commonly used in the program code of the CD-I disc itself, to facilitate programming: these are discussed in more detail in Chapter 11, Programming.

Notes

1 Dr. David Matthewson, *Revolutionary Technology*, Newnes Technical Books, Sevenoaks, 1983, p. 109.

2 Laura Buddine, TigerMedia, speaking at CD-ROM Europe, London, 21–23 May 1991.

7

Audio and video on CD-I

This chapter describes the particular qualities of audio and video storage and processing on CD-I, including storage capacities and technical features. It explains CD-I's choice of audio at CD-DA, Level A, Level B and Level C in stereo and mono, and graphic encoding formats RGB, DYUV, CLUT and RLE, as well as the use of CD-I's processing facilities to create special effects and motion.

COMPACT DISCS

All CD platforms have certain features in common, and several were designed to exploit this common heritage compatibly. By sharing many of the same features, audio and data discs can both be played in a CD-ROM drive, and a CD-I delivery system can handle CD-DA and Photo CD. The common features of all CDs, and CD-I's special properties, are described more fully in Chapter 6, CD-I Discs and Drives.

However, compatibility amongst CD-based systems is no longer so tidy in practice as in theory: the emergence of desktop video, CDTV and DVI technology means that no one system in the market of the early nineties can handle all the possible applications of compact discs to multimedia presentations. Nonetheless, for consumers and corporate users of CD-I, there are still many advantages in the inherent compatibility between the several platforms designed for the mainstream of compact disc products.

CD storage capacities

A compact disc is a 12cm/4.75 inch platter which can be turned variously to many purposes. The disc can hold some 650MB of data of various kinds: design determines

the type, quality, variety and volume of information on any one disc. Dedicated to a single purpose, the compact disc can be processed as:

- A CD-DA audio disc, which can hold up to 72 minutes' worth of top-quality stereo sound – enough for all the numbers in a Broadway musical.
- A CD-ROM data disc, which typically holds up to 650MB of digitized text and diagrams – enough for the complete *CIA World Factbook*, with data on every country in the world, and 248 maps.
- A LaserDisc 'single', which can combine six minutes of analogue video with 20 minutes of top-quality digital stereo sound.
- A Photo CD slide show with up to 100 high-resolution images which users can manipulate on the screen with a domestic player or within a desktop publishing or audio-visual editing facilities.

These formats have precise capacities because they concentrate on data of one type. But multimedia formats such as CD-ROM XA and CD-I can contain virtually any combination of material, providing that the total package satisfies the ultimate technical demands of the format – and, of course, other limitations such as budgets and schedules. One CD-I disc might hold:

- Audio material including music, speech and sound effects, in mono or stereo, at four levels of quality (equivalent respectively to CD-DA discs, new vinyl discs, FM radio and AM radio).
- Photographic images from sources such as colour transparencies and slides.
- Graphics, either produced on a computer or transferred from conventional artwork (including archival material such as documents, maps and drawings).
- Moving pictures of various kinds, from computer-generated animation to video, displayed at speeds from slow- to full-motion, and in sizes varying from a tiny window to the full extent of the screen.
- Text and data including sub-titles, captions, credits, menus and indexes as well as screens devoted to written information.

The graphic material, like the audio, can be presented in various ways and levels of quality: true photographic images can draw on up to 16 777 216 colours for precise and subtle definition, while simple animated cartoons may use only a handful of bright colours.

As well as the familiar 12cm/4.75 inch, there is also a 8cm/3 inch format which may become more widely used if its small size becomes a significant advantage in the design

and distribution of electronic books. Its structure and potential are much the same as the standard CD, within the limits of its physically smaller size and storage capacity.

The structure of the CD-I disc, and the features which it shares with other compact disc formats, are described in Chapter 6, CD-I Discs and Drives. The designer would do well to read that chapter, just as the programmer must consider this one; both should appreciate two important technical points:

- All the data on a CD-I disc – video, audio, text and control programs – are processed as tiny units called sectors, each of which typically holds about 2KB worth of information.
- A sector can only contain one type of data (e.g. audio or video); however, the various sectors which comprise any one image or audio recording, can be interleaved, one type with another, when the data are processed, to ensure a steady flow of information of various kinds to all parts of the delivery system (Fig. 7.1).

Figure 7.1: Interleaved sectors for two audio tracks and one video signal

- The CD-I delivery system has a uniform and finite data processing capacity of 75 sectors per second which, allowing for variations in the average of 2KB per sector, produces an ultimate data transfer rate of up to 170KB per second.
- The CD-I designer and programmer must always ensure that, whatever information is being presented, the data required can be processed within the limits of 75 sectors, or 170KB, per second.

The programmer's task is described in more detailed in Chapter 11, Programming. The balance of this chapter addresses the specific audio-visual features which CD-I offers multimedia designers, and the nature of the equations which the designer must make to accommodate the intellectual and creative demands of the programme, and the technical constraints of the CD-I delivery system.

CD-I AUDIO: TECHNICAL OVERVIEW

CD-I can of course carry the same top-quality digital audio as a CD-DA disc, but the system also has a special audio encoding technique, Adaptive Differential Pulse Code Modulation (ADPCM), developed especially for CD-I by Sony, which provides another range of more versatile options.

In practice, there is little need for CD-DA, for CD-I offers audio at three other levels, the best of which offers high quality with a versatility which CD-DA does not offer. Their features are summarized in Figure 7.2, and explained below.

One compact disc can carry a little over an hour's worth of top-quality music, and nearly 20 hours' worth of telephone-quality speech.

- At CD-DA level, one disc can hold up to 72 minutes' worth of top-quality digital audio (equivalent in quality to SuperHi-Fi).
- At Level A, one disc can hold up to 2.4 hours' worth of high-fidelity stereo sound (equivalent in quality to a new vinyl record).
- At Level B, one disc can hold up to 4.8 hours' worth of mid-fidelity stereo sound (equivalent in quality to FM broadcast radio).
- At Level C, one disc can hold up to 9.6 hours' worth of low-fidelity stereo sound (equivalent in quality to AM broadcast radio).

	CD-DA	Level A	Level B	Level C
Audio type	PCM	ADPCM	ADPCM	ADPCM
Stereo channels	1	2	4	8
Mono channels	0	4	8	16
Stereo capacity	1.2h	2.4h	4.8h	9.6h
Mono capacity		4.8h	9.6h	19.2h
Sampling rate	44.1kHz	37.8kHz	37.8kHz	18.9kHz
Frequency response	20kHz	17kHz	17kHz	8.5kHz
Bits per sample	16	8	4	4
Datastream (stereo)	100%	50%	25%	12.5%
Datastream (mono)	0	25%	12.5%	6.25%
Bytes (stereo)		85 KB/sec	42.5 KB/sec	21.3 KB/sec
Bytes (mono)		42.5 KB/sec	21.3 KB/sec	10.6 KB/sec

Figure 7.2: CD-I audio facilities

CD-DA by definition is dedicated to stereo, but in mono, the capacity is doubled at Levels A, B, and C (Fig. 7.3):

- At Level A, 4.8 hours' worth of high-fidelity sound.
- At Level B, 9.6 hours' worth of mid-fidelity sound.
- At Level C, 19.2 hours' worth of low-fidelity sound.

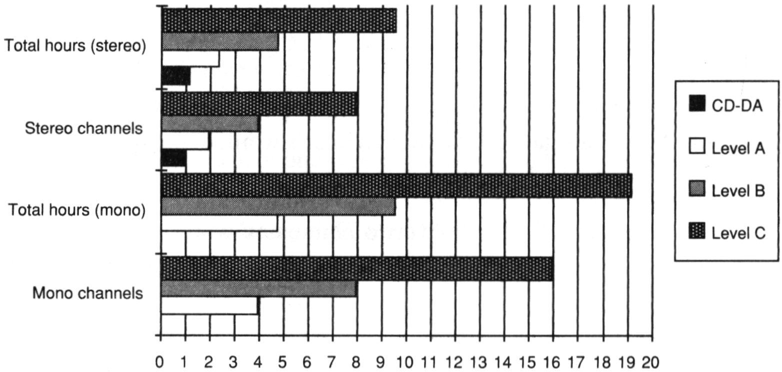


Figure 7.3: CD-I audio channels' storage capacity

Furthermore, each level has separate audio channels, which can be paired to produce stereo, or recorded separately to increase the storage capacity of the disc.

- Level A can employ up to 2 stereo, or 4 mono, channels.
- Level B can employ up to 4 stereo, or 8 mono, channels.
- Level C can employ up to 8 stereo, or 16 mono, channels.

It is, therefore, by recording something different on each of Level C's 16 separate channels, that one disc can hold over 19 hours' worth of sound. Of course, with all that audio, there would be no room for anything else: in practice, these maximum capacities simply illustrate the effect of different levels of quality on the ultimate storage capacity of the disc.

The four encoding methods vary in the quality of sound which they record (and, thus, re-deliver without enhancement). CD-DA demands virtually all the storage and processing resources which a compact disc affords, and hardly leaves room for other information. ADPCM is a form of compression, which reduces the data in CD-DA's PCM recording technique to a choice of quality levels appropriate to sound being processed, and the other demands on the system (Fig. 7.4).

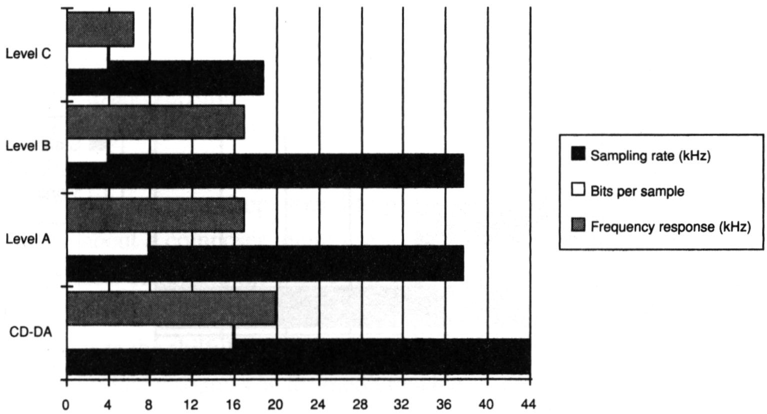


Figure 7.4: CD-I audio quality levels

- CD-DA, with the best quality sound, has a sampling rate of 44.1kHz (i.e. 44 100 samples per second), and a frequency response of 20kHz, with 16 bits per sample – higher than the most acute human perception.
- Level A, with hi-fi quality sound, has a sampling rate of 37.8kHz, and a frequency response of 17kHz, with 8 bits per sample – lower than CD-DA, but still of a higher quality than most conventional audio systems, and equal to the demands of a highly-trained human ear.
- Level B, with FM radio quality sound, also has a sampling rate of 37.8kHz, and a frequency response of 17kHz, but with only 4 bits per sample: the audio quality is accordingly lower than that of Level A.
- Level C, with AM radio quality sound, has a sampling rate of 18.9kHz, and a frequency response of 8.5kHz, with 4 bits per sample – a dramatic drop from Level A, but still better than, for example, the quality of a clear telephone line.

The other factor which considerably affects the trade-off between quality and economy, which designers constantly face, is the percentage of the data channel which these four levels of audio require – that is, how much space and processing power is likely to be occupied by the audio data alone at any one level (Fig. 7.5).

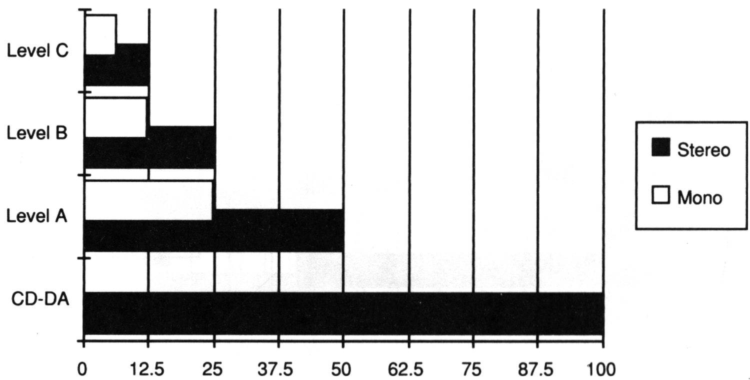


Figure 7.5: CD-I audio in the data channel

- CD-DA's two (stereo) tracks occupy 100 per cent of the data channel – which leaves no room for any other information, which is one reason why CD-DA is inappropriate for most multimedia applications.
- Level A occupies 50 per cent of the data channel in stereo, and 25 per cent in mono.
- Level B occupies 25 per cent of the data channel in stereo, and 12.5 per cent in mono.
- Level C occupies 12.5 per cent of the data channel in stereo, and 6.25 per cent in mono.

Hi-fi stereo obviously requires much more storage space than low-fi mono. It should be clear, therefore, that:

- Level A is generally reserved for recording music which would benefit from high-quality reproduction – an excerpt from a concerto in a programme about its composer, for example.
- Level B is more appropriate for music which does not need such accurate reproduction – a background track, or theme tune, perhaps.
- Level C does little service to good music, but provides excellent reproduction of the spoken word and, of course, most sound effects.

Thus, for the multimedia designer, every piece of audio in the programme must be assigned a quality level – A (hi-fi), B (mid-fi) or C (low-fi), in stereo or mono – which affects both the way in which it is reproduced, and the share of disc space which it demands. The management of these resources is clearly of prime importance in music

programmes, but presentations of many kinds benefit enormously from the subtle deployment of aural effects.

The audio track can do much to enhance the mood or increase the impact of visual information, to add verisimilitude or heighten the atmosphere, or simply to lighten the weight of long instructional sequences or text screens. The knack which the multimedia designer should cultivate particularly is that of shifting the level of quality as users' attention moves from sound to pictures, and back again. For example, a programme about a composer might use the highest quality levels, in stereo, when musical extracts command the user's full attention, but then quickly switch back to lower levels for speech, background music or sound effects. The same principle of course applies to the skilful deployment of graphics and video. It is often possible to concentrate limited resources on the medium which is most likely to engage the larger part of users' attention at any one time.

Soundmaps

Audio can be stored as soundmaps in the CD-I player's memory. A sound effect or 'sting', or a snippet of music, which is going to be used several times in the course of the programme, can quickly be transferred to the player's random access memory (RAM), and held there until it is replaced by another soundmap, or until the programme is over and the system is switched off.

This saves both search time and processing power, by keeping one part of the audio-visual presentation within easy reach while the system devotes the greater part of its energies to retrieving and processing more complex data from another location. It also provides a handy resource to distract users' attention during the slight delays inevitable in finding and loading some complex information.

On the disc or in soundmaps, audio is encoded in the sound groups described in the previous chapter. A soundmap comprises a block of sound groups, noting both the number of groups in the block, and a code to indicate how they are encoded. Soundmaps can be used and combined in various ways:

- The same soundmap may be looped back under program control, to play as long as it is required, or even indefinitely (for example, to supply a minimalist soundtrack).
- Two mono soundmaps can be 'mixed' to create the impression of a stereo soundmap, although they cannot actually make true stereo.

As the audio tracks are already immutably recorded, this is not mixing in the conventional sense so much as rearranging to combine, say, mono Soundmap A and mono Soundmap B to produce 'stereo' Soundmap C; alternatively, complementary sectors from two stereo soundmaps can be combined to create a third, slightly different, stereo soundmap (Fig. 7.6).

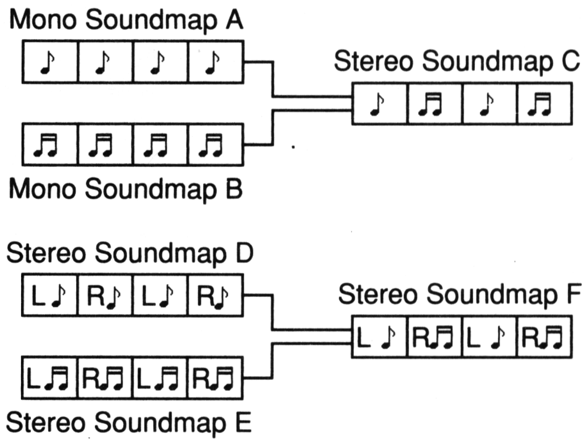


Figure 7.6: Mixing soundmaps

Soundmaps of different types can similarly be mixed, for example, to combine occasional sound effects with background music in a game. The music sectors on the disc are arranged as usual (allowing for the slight time delays in loading a soundmap). Sound effects or stings are also processed as soundmaps so, when an effect is required, it is simply mixed with the next music soundmap in the sequence. This technique supplies a continuous soundtrack with minimal processing, and leaves the rest of the system free to concentrate on the game or presentation.

Typical soundmaps provide the effects for a hit or a miss in a shoot-'em-up action game. There are many examples in the sound of club and ball connecting, and the spontaneous applause or sympathetic murmur of the crowd in CD-I's gallery of golfing programmes.

Soundmaps are buffers in memory which can hold non-real-time audio, and transfer these data to memory at some convenient point in the presentation, to be stored there until they are needed: they are not retrieved, processed and displayed like real-time files. Soundmap data are processed through the audio processor like any other audio data (as explained in the previous chapter). Thus, any one soundmap must occupy an integral number of contiguous sectors – that is, the soundmap must fill at least one

sector and, if it requires more than one, must fill all of those (even with a bit of silent audio to make up the balance) and store them together. This ensures that the right volume of data passes through the CD-I system in a steady stream.

The chart below summarizes typical response times for soundmaps at various levels (assuming an initial delay of one sector), in seconds and milliseconds per sector, and in relation to every 100KB of data. A soundmap in Level B stereo, for example, offers a satisfactory response time of 53ms, but allows only 2.32 seconds' worth of audio for every 100KB of data. Soundmaps must be carefully planned and deployed to make the best use of all their features (Fig. 7.7).

Audio Level	Response time per sector (seconds)	Response time per sector (milliseconds)	Response time per 100KB (seconds)
Level A stereo	0.027	27	1.16
Level A mono	0.053	53	2.32
Level B stereo	0.053	53	2.32
Level B mono	0.107	107	4.64
Level C stereo	0.107	107	4.64
Level C mono	0.213	213	9.29

Figure 7.7: Typical response times for soundmaps

Soundmaps of course are held for processing within the player itself. The CD-I player can hold up to one megabyte (1024KB) of volatile data, in two banks of 512KB apiece. The calculations for the space required by any one soundmap are relatively straightforward.

- Level C stereo, for example, occupies 12.5 per cent of the data channel, so a single second of audio at this level represents 12.5 per cent of 170KB, or just over 21KB: a two-second audio sting would thus require 43KB of storage space at Level C.
- A five-second jingle in Level B stereo, occupying 25 per cent of the data channel (or 43KB per second) would require 213KB, or just under half the space available in one bank.

The player's RAM also accommodates graphic drawmaps, which are discussed separately below.

Special effects

CD-I can support a range of special effects for sound. These include:

- Panning, to create the impression of movement from one side to another – which can be equally effective for action, such as the sound of an airplane swooping down from the clouds and off into the horizon, and subtler effects such as the concentration of ambient noise from one part of a playing field to another during the course of a sporting event.
- Attenuation, to provide effects such as fades from one scene to another, or to allow users to control the level of volume in various parts of the programme.

The inclusion of a Musical Instrument Digital Interface (MIDI) driver in some CD-I (and CDTV) players also allows users to connect their own electronic instruments to the hi-fi or player, so that programmes such as Sonic Images' *Private Lesson* series can actually allow the music student to play along with arrangements on the disc.

Delivery systems

For audio as for video, the quality of the output which any one user will eventually receive of course depends on factors over which the designer has no control. For audio, the range of options varies from the speakers on a small, inexpensive television through to the facilities of a high-quality stereo sound system, if the CD-I player has been connected to the hi-fi.

In a custom-made professional application (for training, say, or marketing), the client can usually specify exactly what components will feature in the delivery system, and the designer can work to that specification. But in designing consumer products, it is never safe to assume even that someone who buys a CD-I on classical music will hear it through an expensive hi-fi. It is safest, therefore, to test all audio output on a variety of output devices (including headphones of various qualities, which many people use particularly to heighten the effect of action-packed games).

CD-I VIDEO: TECHNICAL OVERVIEW

One of CD-I's particular strengths is the variety of options which it offers for the encoding and delivery of still and moving images. Even before the inception of full-motion, full-screen video, one CD-I disc could hold:

- Up to 6340 photographic images (e.g. slides, colour transparencies or still video frames), combining up to 16 777 216 colours;
- Up to 6340 graphics (whether created with computer software or as conventional artwork) with up to 32 768 colours on any one screen;
- Animation (e.g. drawings with limited motion) with up to 128 colours.

These images can be displayed over the full screen, or within windows (typically, with a larger still image, or associated textual material, filling the rest of the screen). They can also employ any number of colours from the subtle shading of full-colour photography or high-quality computer animation to the bright palettes of children's cartoons. Until the advent of full-motion full-screen video, movement is somewhat restricted, but can typically fill an eighth of the screen with partial-motion. All these factors – size, colour, detail, movement – greatly influence the sheer quantity of visual data which can be stored on a single disc.

Screen resolution

CD-I images can be displayed at three levels of resolution. These specifications are usually expressed in terms of pixels, the individual picture elements which are the smallest unit of visual information in digital display systems. Pixels are rather like tesserae in an extremely tidy mosaic: many tiny pixels create a more finely-detailed image than a few large ones.

But where the tesserae in a mosaic are often irregular, pixels are uniformly shaped and arranged across any one screen. However, the aspect ratio (height to width) of the pixel adapts to the aspect ratio of the screen on which it is displayed, so the actual shape of the pixel changes slightly between NTSC and PAL/SECAM, and at different levels of resolution. This – together with the convex shape of most television screens, accounts for the slight distortion which is particularly noticeable in geometric shapes such as circles and triangles.

- Normal resolution is appropriate (if not yet equal) to the picture quality of a properly-tuned broadcast television receiver.
- Double resolution has twice as many pixels per line (that is, horizontally) as normal resolution, but the same number of lines per screen. Double resolution is equivalent to the image quality of a computer with VGA-standard colour graphics.
- High resolution has twice as many pixels both horizontally and vertically as normal resolution (that is, twice as many pixels per line, twice as many lines per

screen). High resolution is equivalent to the best quality of digital video generated in a professional production facility.

In the same block of data, where normal resolution would use only four pixels to describe the image there, double resolution will use eight, and high resolution will use 16. Each pixel typically represents one byte of computer data so, the more the pixels, the more space and power required to store and process the image (Fig. 7.8).

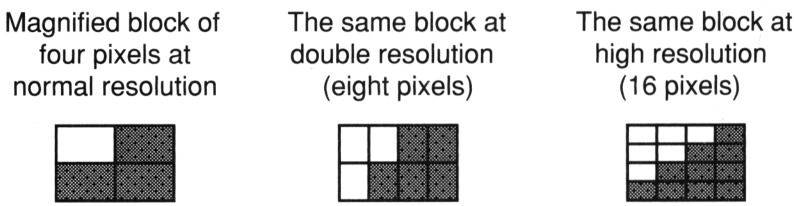


Figure 7.8: Pixels at normal, double and high resolution

Clearly, by breaking the image into 16 discrete units of visual information, high resolution produces smoother lines, finer detail, and more subtle use of colours than normal or double resolution.

- Normal resolution is sufficient for most of the audio-visual material in a CD-I programme.
- Double resolution provides a sharper image for detailed text and graphics.
- High resolution is particularly useful for fine detail such as text (including captions and sub-titles) in complex character sets such as the Japanese syllabary, Kanji, which require more visual detail than Roman or Cyrillic alphabets.

Normal and double resolution, like computer displays, are not interlaced and are thus free of many problems associated with interlaced television and video signals. High resolution images, with so much more data to process, are interlaced, and accordingly subject to flicker (particularly in very thin lines, or between areas of high contrast, both of which should simply be avoided).

CD-I is ultimately independent of national broadcast television standards, of course, but most of the world's televisions and video monitors are still designed to meet one of the two prevailing standards for the composition of the picture on the screen. This means that the actual number of pixels displayed in users' own delivery systems will depend on whether that TV or monitor employs the NTSC or PAL/SECAM standard (Fig. 7.9):

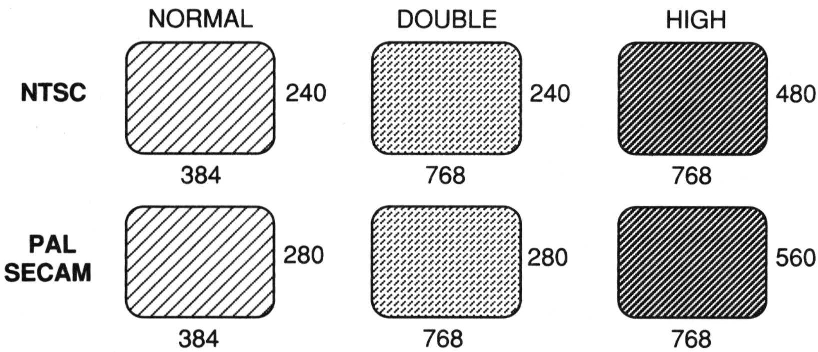


Figure 7.9: Pixels per screen in NTSC, PAL and SECAM

- Normal resolution offers 384x240 (NTSC) or 384x280 (PAL/SECAM), a total area of 92 160 (NTSC) or 107 520 (PAL/SECAM).
- Double resolution offers 768x240 (NTSC) or 768x280 (PAL/SECAM), a total area of 184 320 (NTSC) or 215 040 (PAL/SECAM).
- High resolution offers 768x480 (NTSC) or 768x560 (PAL/SECAM), a total area of 368 640 (NTSC) or 430 080 (PAL/SECAM).

NTSC, of course, displays 525 lines where PAL/SECAM displays 625 (as Appendix I explains) – a practical difference of 40 lines for CD-I at normal resolution. To address this, designers may add a narrow border to the top and bottom of the screen (to supplement NTSC displays on PAL monitors), or simply start the image display on line 20 of the PAL screen, which effectively leaves 20 blank lines at the bottom as well.

This is further complicated by the slightly convex curve of most televisions and monitors, and instability of the image around the very edge of the screen (caused by overscanning). All visual material should be confined to the 'safe area' which is free from distortion, and bound to be seen on all screens, no matter what their quality.

- Normal resolution offers a safe area of 320x210 (NTSC) or 320x250 (PAL/SECAM), a total safe area of 67 200 (NTSC) or 80 000 (PAL/SECAM).
- Double resolution offers a safe area of 640x210 (NTSC) or 640x250 (PAL/SECAM), a total safe area of 134 400 (NTSC) or 160 000 (PAL/SECAM).
- High resolution offers a safe area of 640x420 (NTSC) or 640x500 (PAL/SECAM), a total safe area of 268 800 (NTSC) or 320 000 (PAL/SECAM).
- At all resolutions, the safe area effectively represents a window within the full screen of 72.9 per cent (NTSC) or 74.4 per cent (PAL/SECAM).

	RGB 8:8:8	RGB 5:5:5	DYUV	CLUT 8
Description	Computer graphic format	5 bits for each level of red, green, blue	Delta YUV	8-bit Colour Look-Up Table
Best use	Digital capture of video and graphics	Highly detailed images	'Natural' photos, slides, still video	Captured or computer-generated graphics
Resolution	Normal	Normal	Normal	Normal
CD-I Plane	N/A	Both	A or B	B only
Colours	16 777 216	32 768	16 777 216	256 out of 16 777 216
Bits per pixel	24	16	16 per pixel pair	8
Typical image size	600KB	210KB/PAL 180KB/NTSC	105KB/PAL 90KB/NTSC	105KB/PAL 90KB/NTSC
Nº per disc	1080	3170	6340	6340
Ratio to RGB		3:2	3:1	3:1

Figure 7.10 (a): CD-I graphics facilities

The amount of computer data needed to store an individual image is calculated on the basis of screen size. An image which fills the screen at normal resolution requires 92 160 bytes of data in NTSC (i.e. 384x420), and 107 520 in PAL/SECAM (i.e. 384x280). A kilobyte of data is actually 1024 bytes (2^{10} in the binary notation used by digital computing systems), which works out to 90KB per image in NTSC, and 105KB in PAL/SECAM. Where the resolution is higher, obviously, more data are required, and the number of bytes needed to store the image increases accordingly.

Photo CD, by comparison, scans 2048 lines with 3072 pixels per line, for each of the red, green and blue levels in the colour image – some 18 874 368 pixels per image. To fit even 100 images on a single CD at this level of resolution, Photo CD employs a hierarchical compression system with a 'base image' of 768x512 (similar to CD-I's high resolution) for ordinary TV or computer monitors, plus two files for higher resolution (for HDTV and high-quality enlargements) and two for lower resolution (for the thumbnail on the cover of the jewel box, and multiple-image screen displays).

	CLUT 7	CLUT 4	RLE 7	RLE 3
Description	7-bit Colour Look-Up Table	4-bit Colour Look-Up Table	Run-Length Encoding of CLUT 7	Run-Length Encoding of CLUT 4
Best use	Captured or computer-generated graphics	Detailed text or graphics	Cartoon style animation	Cartoon style animation
Resolution	Normal	Double	Normal	Double
CD-I Plane	A or B	A or B	A or B	A or B
Colours	128 out of 16 777 216	16 out of 16 777 216	128 out of 16 777 216	7 out of 16 777 216
Bits per pixel	7	8 per pixel pair	7	8 per pixel pair
Typical image size			Varies	Varies
Nº per disc			Varies	Varies
Ratio to RGB			10:1	

Figure 7.10(b): CD-I graphics facilities

DYUV, RGB 5:5:5, CLUT, RLE

CD-I can employ standard Red-Green-Blue (RGB) computer graphics encoding techniques, like other computer-based products. However, a single RGB graphic may easily require 300KB of storage space on disc and in the system's memory, as well as associated data transfer and processing capacity. CD-I offers a choice of techniques to reduce the amount of data stored and processed with each image, with a choice of techniques adapted to the various demands of photos, slides and video stills, computer text and graphics, animation and images transferred from conventional artwork and archival sources.

CD-I offers four basic encoding and compression techniques for images of various kinds. Some of these in turn offer different levels of quality (not unlike the audio levels), so the options ultimately available to the astute designer afford a wide choice of technical and creative solutions (Fig. 7.10).

The various approaches to displaying images on screens, as convoluted as they seem, simply reflect the principles of human vision. The human eye processes images

and colour separately (which is why people with colour defective vision may have keen eyesight, while myopes may be excellent colourists). The retina itself has more receptors which are sensitive to brightness than colour, so normal human vision is more sensitive to changes in luminance than in hue.

Television and video, obviously, process images and colour separately, so a black-and-white set can receive images but not colour. Computing's RGB colour space divides each pixel into the red, green and blue components of every colour. Imaging systems which employ the YUV colour space exploit the difference between brightness and colour by dividing the pixel between luminance (Y) and hue (U and V): Y is effectively the black-and-white picture, U and V add the colour signal. This means that luminance and hue can be processed separately: DVI technology, for example, compresses the colour signal (to which viewers are less sensitive) more dramatically than the luminance signal (Fig. 7.11).

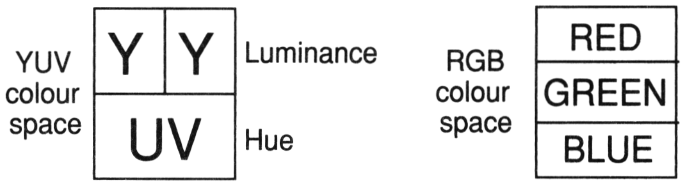


Figure 7.11: YUV and RGB encoding

- Delta YUV encoding (DYUV) assigns a value to the luminance signal (Y) of each pixel, and then defines hue (U and V) separately in relation to this. Y comprises six parts of green to three of red and one of blue, so that:

  $$Y = 0.6\ \text{Green} + 0.3\ \text{Red} + 0.1\ \text{Blue}$$
  $$U = \text{Red} - Y$$
  $$V = \text{Blue} - Y$$

  DYUV works in pixel pairs, assigning a Y value to each individual pixel, but calculating the UV value for each pair; this requires two bytes of data for each pixel pair. DYUV typically compresses a single photographic image at a ratio of 3:1, compared with standard RGB computer graphics techniques.
- Standard RGB encoding provides 8-bit colour – that is, 2^8 or 256 separate levels of colour for each of the three red, green and blue components of the colour signal. One simple way to compress the volume of data in this record, without significant loss of quality, is to reduce the number of colours to, say, 5-bits (i.e. 2^5 or 32 apiece). This form of encoding is known as RGB 5:5:5 (i.e. 5-bits for each level

of RGB), a notation by which standard 8-bit encoding is distinguished as RGB 8:8:8 (i.e. 8-bits for each level of RGB). The compression ratio thus achieved is effectively 8:5 or, more conveniently, 3:2.

- Colour Look-up Table (CLUT) encoding employs a simple economy, by creating individual tables or palettes of up to 256 colours at one time from the ultimate choice of 16 777 216, and assigning each colour a discrete address within the table. Thus, in real-time, the system has only to identify the table, and the colour's address, to simplify the search for the precise colour code from one in 16 777 216 to one in 256. This effects compression ratios of 3:1 (so DYUV and CLUT effect the same savings, but produce images of different visual quality). In fact, CLUT offers three levels: 8-bit CLUT provides up to 256 colours at a time, 7-bit CLUT provides up to 128, and 4-bit CLUT provides up to 16 (see Figs. 7.12 and 7.13).
- Run-Length Encoding (RLE) also uses the techniques described in Chapter 2, Multimedia Platforms, by analysing the colour displayed in every horizontal line of pixels in an image. RLE encodes the colour of the first pixel in the line, and then records the length of the line (in pixels) for which this colour runs, until another colour appears. For images which contain large blocks (i.e. many long runs) of the same colour, this can effect considerable savings.

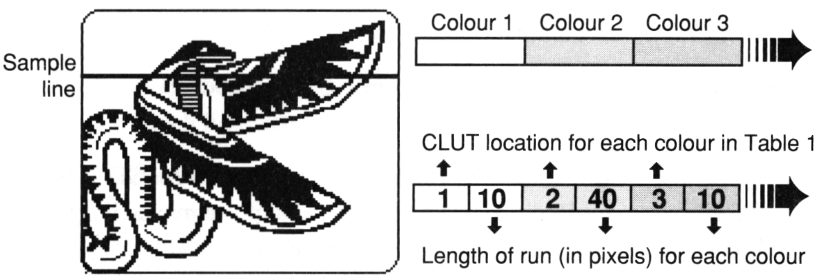


Figure 7.12: Colour Look-Up Table (CLUT) & Run-Length Encoding (RLE)

The use of colour is one of the main ways in which these four basic encoding systems (and their variations) effect their economies of scale. The '16 million' ultimately available actually represent the 16 777 216 combinations possible with 24-bit colour, or 256 hues available on each of the red, green and blue palettes (2^{24}=16 777 216). In practice, the first current generation of CD-I players support only 6 bits for each level of red, green, and blue, which represents 262 144 colours (2^6 for each level).

- DYUV, with a 24-bit display, could ultimately offer CD-I's full range of 16 777 216 colours (which is, effectively, more than a highly trained human eye

could detect), a wide range of which are typically required by the subtlety of photographic images and flesh tones.

- RGB 5:5:5, with a choice of 32 values for each of the three prime colours (red, green and blue), offers a choice of 32 768 colours, which is sufficient for images which do not require photographic realism.
- CLUT 8 offers a palette of 256 colours at any one time, from the ultimate choice of 16 777 216; CLUT 7 offers 128 colours in a palette, and CLUT 4 offers 16 in double resolution.
- RLE 7 employs a palette of 128 colours at a time, while RLE 3 (which codes pixel pairs at double resolution) offers a choice of eight, which makes text and images at this end of the scale crisp and bright, if not subtle.

These four techniques are variously suited to CD-I's three levels of resolution:

- DYUV works at normal resolution but, for high resolution, quantized high-resolution Y (QHY) encoding can be employed to enhance the luminance signal to the level which high-resolution displays demand.
- RGB 5:5:5 is only available at normal resolution.
- CLUT 8 and CLUT 7 are available at normal resolution, and CLUT 4 at double resolution.
- RLE 7 is available at normal resolution, and RLE 3 at double resolution.

Like the various levels of audio, these different types of encoding offer the choice of more or better images:

- DYUV encoding typically demands 105KB per image in PAL/SECAM (90KB in NTSC), so a 650MB disc could hold some 6340 photographic images.
- RGB 5:5:5 demands around 210KB per image in PAL/SECAM (180KB in NTSC), so the same disc could hold some 3170 complex computer graphics.
- CLUT 8 also requires about 105KB per image in PAL/SECAM (90KB in NTSC), so a 650MB disc could also hold 6340 computer graphics, images converted from conventional artwork, charts or other illustrative material.
- Run-Length Encoding typically reduces all the data needed to register one stretch of solid colour to a two-byte code. Thus, where a line of 255 pixels contains only one colour, two bytes of data would suffice to define that colour and specify the length of the run for a line which might otherwise require 180 bytes even in CLUT 4. The greater the redundancy in the image, the greater the savings in RLE. A ratio of 10:1 is not uncommon.

Clearly, this range of options means that the four encoding methods are suited to material of quite different kinds.

- DYUV encoding is best suited to true photographic or still video images, which are both finely detailed and richly or subtly coloured and shaded, and so require reproduction of the highest quality. However, the U and V signals have reduced resolution horizontally, which does not support sudden changes in hue. The use of delta encoding with non-linear quantization means that roughly three pixels are required to change to exactly the right colour: where DYUV is used in partial-screen updates, it is important to restore the colours to the right of the updated image accurately. At normal resolution, vertical white lines may show jagged right edges, and diagonal lines may look 'stepped' rather than smooth: encoding, resizing and filtering a high resolution image during production can reduce these effects on presentation.
- RGB 5:5:5 provides crisp displays of graphics and photos without the demands of DYUV or the limitations of CLUT but, as the compression ratio is relatively small, CLUT may be preferred where quantity rather than quality is the main issue.
- CLUT encoding is the most versatile and economic technique for the storage of text and graphics. The colour palettes are limited, but the images stay crisp, and CLUT 4 at double resolution is useful for text, particularly complex character sets or small fonts which require fine detail.
- Run-Length Encoding is, obviously, the preferred method for cartoon-style animation which fills each outline with a single block of colour.

The choice of encoding method has some consequences in the use of special effects – RGB 5:5:5, for example, offers a form of transparency not available in other formats but, as it occupies both image planes, cannot support other effects which depend on the combination of images. These are explained in more detail below.

Encoding

The various types of graphic images within the CD-I system are, of course, encoded differently even at various levels of quality within the same format:

- 16-bit RGB 5:5:5 images, which occupy both image planes, are recorded in two separate banks of eight bits each. The upper bank contains 'high bits' and the lower bank contains 'low bits'. As well as levels of red, green and blue, RGB 5:5:5 can also contain colourless transparency bits. By definition, RGB 5:5:5 supplies the

most significant five bits for each level of red, green, and blue, and leaves the remaining three bits empty in the 8-bit bank; five bits for each of three leaves one bit in the 16-bit code for a transparent bit.

- 16-bit DYUV images at normal resolution are encoded as a set of four pixel pairs, comprising four bits each (or two bytes altogether).
- CLUT images are recorded with one byte per pixel at normal resolution, and one per pixel pair at double resolution. CLUT 8 uses the entire byte for its eight bits (256 colours); CLUT 7 leaves one bit spare; and CLUT 4, at double resolution, uses four bits for each pixel.
- RLE images must first record the address of the selected colour in the relevant look-up table, and then the length of the run (in pixels) until the next colour appears. In normal resolution, RLE 7 employs seven bits to describe the CLUT address of a single pixel, and divides this between the address and the run-length for a run of pixels in a line. In double resolution, RLE 3 defines each pixel in a single pair with a separate 3-bit address, and includes both addresses and their common run-length in describing a run of pixel pairs.

Images of different types are decoded differently within the CD-I delivery system.

- CLUT, RLE and RGB 5:5:5 images, which are essentially compressed RGB signals, are converted directly to analogue RGB, with at least six bits (or 64 levels of colour, 2^6) for red, green and blue respectively.
- DYUV, which employs a slightly different encoding method, goes through another stage, to convert its delta codes back to their Y, U and V values, and then matrix these to the appropriate RGB levels for display.

The various stages in the decoding and presentation of graphics and video signals are explained in more detail in the previous chapter.

Drawmaps

Video can also employ 'drawmaps', which store image data from the CD-I disc in the same way that soundmaps store audio data. All images must be stored in RAM before being decoded for display.

The CD-I's dynamic RAM (DRAM) has a maximum storage capacity of one megabyte (1024K), which is divided between two banks of 512KB apiece – one for each video image plane. The player's own operating system needs about 50KB of this, and the rest can be dynamically employed to store audio, text and graphics as they are

required during the programme. Even at 105KB per image in PAL/SECAM for DYUV or CLUT 8 graphics, this affords enough storage capacity to support many special effects (such as those described below) within the player itself.

Drawmaps can be used individually, or in combination – for example, to store the pictograms which represent the magical objects that players often collect and use in an adventure game. When a drawmap is no longer needed, it can be replaced with other, more relevant information; because all this happens entirely within the player, the original image remains untouched on the disc.

Moving pictures

Full-motion, full-screen video was demonstrated from a CD-I disc for the first time at a meeting of CD-I licensees in Tokyo in October 1990, and is to be a standard feature when consumer players are released in Europe in 1992. Players purchased before then are designed to be easily upgraded. Until then, moving images on CD-I are effectively restricted to the choice of Run-Length Encoding for animated sequences, or partial-motion video in windows on the screen.

The options and trade-offs here are, again, simply equations based on the finite processing capacities of the system.

- Video demands a great number of high-quality images to simulate motion even at 15 frames per second with photographic realism.
- The data transfer rate of CD-I is limited to 75 sectors (roughly 170KB) per second. If the whole of this capacity were devoted to digital video images at a rate of 15 per second, each frame would have to be contained within a mere 11.3KB of data (170/15) – with no room for audio, text or program-related data.
- Video is a photographic medium, so DYUV encoding is most appropriate to moving pictures which simulate true video (although CLUT 8 requires the same volume of data, so the functional differences are negligible).
- A typical DYUV image demands 90KB in NTSC (and 105KB in PAL/SECAM). At a transfer rate of 170KB a second, this would only just deliver two full-screen images per second, which is much too slow for video, and yet too fast for slides.

Since the full-screen image cannot be refreshed nearly often enough, the interim solution is to reduce the size of the window in which the video appears.

- If 11.3KB is the maximum allowed per image at a transfer rate of 170KB/second, this represents just over 12.5 per cent of the 90KB needed by a full-screen DYUV

image in NTSC, and just under 11 per cent of the 105KB needed in PAL/SECAM. Thus, the image could fill a window occupying just that percentage of the screen.

- If the frame rate is reduced to 12.5 per second, with the same absolute volume of data, the size of the window can be increased to 13 per cent in PAL/SECAM, or 15 per cent in NTSC. Alternatively, smaller windows leave room in the data channel for audio, text, graphics and other elements of the program.
- A relatively simple compression algorithm can increase the screen size (to, say, 16 per cent in PAL/SECAM, and 19 per cent in NTSC).
- Alternatively, vertical interpolation (described below) can increase the window size to a third of the full screen.

These constraints can be adapted to create two effects:

- Miniature video screens, scaled down to play partial-motion video within windows of at least one-eighth (i.e. 13 per cent) of the total screen size.
- Full-screen video with partial-screen updates, provided within 'invisible windows' which move about the screen to refresh different parts of the image in turn (for example, to animate the features of a talking head, or concentrate the semblance of motion in one part of the screen alone – a single flower head waving in the breeze, for example, against a static background).

It seems entirely likely that, even after full-motion, full-screen video becomes a standard feature, designers will still employ CD-I's many other visual formats, both to vary the content and appearance of the programme, and to make more productive use of storage capacity and processing power.

Image planes

One of the specific features of CD-I's versatility with graphics is the use of four separate planes on which to display the cursor, text, graphics and video images of a typical multimedia programme.

Videotape effectively presents one image plane, for however the programme was compiled in the production studio, all the visual information on the recorded tape is ultimately bound together and presented at the same time. Interactive video usually employs two planes, one supplied by the video source (generally, a LaserDisc) and the other by the computer. In practice, this usually means that text and graphics from the computer are superimposed upon still or moving images from the video recording. CD-I can employ up to four planes independently (Fig. 7.13).

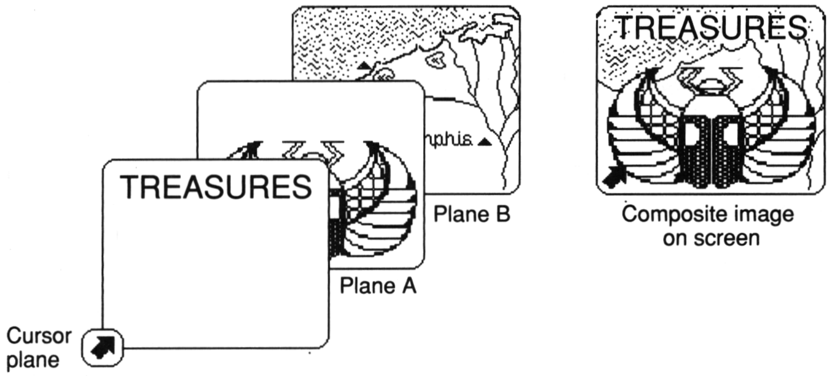


Figure 7.13: CD-I's four image planes

- The cursor plane is restricted to an area 16 pixels wide and 16 pixels high, which can, of course, move anywhere on the screen; the cursor is also restricted to one of a choice of 16 colours.
- The two central 8-bit image planes, Planes A and B, can be encoded separately to provide two layers of graphics, or text and graphics using DYUV, CLUT or RLE encoding. They can also be merged and coded as one for RGB 5:5:5, which requires twice as much data as the other graphic encoding methods.
- The backdrop plane will eventually be used for full-motion, full-screen video, but until then tends to be filled with a single background colour (from a fixed choice of 16, with a default colour of blue) or, in some systems, with images from an external video source.

It is the two central planes, A and B, which offer the designer a range of encoding facilities, and some constraints. They can be displayed in either order (A over B, or B over A) to create the various special effects, described below, which CD-I provides entirely within the delivery system. The final choice of effects and planes, however, should be made with respect to some technical considerations.

- There is one colour look-up table within the CD-I player's video decoder, with 256 addresses.
- The 16-bit colour of RGB 5:5:5 demands the capacity of both planes simultaneously, and leaves no room for other graphics (such as CLUT and RLE overlays) to provide additional effects, captions or other facilities.
- It is so far impracticable to support both planes with a full table each, so the 8-bit colour of CLUT 8, which employs the whole table, is consigned to Plane A alone.

- The 7-bit formats, CLUT 7 and RLE 7, divide the table between the two planes, with 128 colours in each.
- CLUT 4 uses only the first 16 entries in each of these halves; and RLE 3 uses only the first eight entries.

DYUV images can be displayed in both planes simultaneously, to create an effective photographic montage. However, the complexity of DYUV images, with their large range of colours, effectively occupies most of the system's volatile storage and processing capacity, so displays of this kind will not easily support even partial-screen updates or rapid changes between screens. Figure 7.14 illustrates the possible combinations of encoding methods and image planes.

	Plane A OFF	Plane A DYUV	Plane A CLUT 8	Plane A CLUT 7	Plane A CLUT 4	Plane A RLE 7	Plane A RLE 4
Plane B OFF	✔	✔	✔	✔	✔	✔	✔
Plane B RGB 555	✔	✘	✘	✘	✘	✘	✘
Plane B DYUV	✔	✔	✔	✔	✔	✔	✔
Plane B CLUT 7	✔	✔	✘	✔	✔	✔	✔
Plane B CLUT 4	✔	✔	✘	✔	✔	✔	✔
Plane B RLE 7	✔	✔	✘	✔	✔	✔	✔
Plane B RLE 4	✔	✘	✘	✘	✘	✘	✘

Figure 7.14: Graphics encoding on Plane A and Plane B

- As CLUT and DYUV occupy one plane at a time, a photo encoded in DYUV on Plane B can be combined with text and graphics in a CLUT format on Plane A.
- CLUT images on both screens leave considerable room in the data channel for frequent updates, or the demands of audio at the higher levels or in stereo.
- CLUT 8 provides overlays of the highest quality and versatility, but CLUT 7 supports faster screen updates and simple animation, and CLUT 4 is particularly useful for text or graphics which benefit from the sharpness of double resolution.
- CLUT 8 can only be used with DYUV on the second plane, but CLUT 7 can be displayed on both planes simultaneously, or combined with overlays in CLUT 4 and RLE (for example, to lay animated figures against a static background).

Different encoding techniques can also be combined on one plane with the use of sub-screens, which are described below. Through the Display Control Program (DCP) described in Chapter 6, CD-I Discs and Drives, every line on every screen can be discretely coded to support a variety of graphics and effects simultaneously.

Sub-screens

The versatility of separate image planes is further enhanced by the use of sub-screens within each plane. These are horizontal bands which can contain additional information, and even be coded separately, from the rest of the plane. The designer alone determines their number, size and location, for there can be as many discrete sub-screens as there are lines in the screen.

A sub-screen could be used to display optional text such as sub-titles or captions, perhaps even with a choice of colours or locations to suit the various tastes and needs of individual viewers.

The sub-screen can also be used to provide partial-screen updates efficiently in sequences which require variety and motion. In an adventure game, for example, users may spend much time roaming the corridors of an enchanted castle or haunted house, and encounter many different rooms; yet a handful of basic screen images can be updated and modified with the selective use of sub-screens to create a variety of locations from a single collection of visual elements, and to simulate movement in all four directions within each room.

Sub-screens can also be used to combine encoding techniques – for example, to display text or graphics in double resolution (i.e. CLUT 4 or RLE 3) within a screen at normal resolution. This enhances complex character sets, or large simple graphics which benefit from the smoother outlines that double resolution provides.

Sub-screens and partial-screen updates can effect considerable savings in processing time and power, by supplying new information only where it is absolutely required, and refreshing each part of the screen at the appropriate rate.

Text

CD-I can handle text as a computer does, as characters in a data file which are displayed on the screen, in the designer's choice of font, colour and typographic effects. This demands the basic set of instructions which describe each font, so all the fonts required by the programme must be loaded into the player's RAM.

The system itself, of course, has a default font in ROM so that it can display error messages and other vital information on the screen. This conforms to the standard Latin character set defined by ISO 8859-1, and includes diacritic marks, basic mathematical and currency symbols, and the other special characters found on a computer keyboard. This character set can be used by designers for individual applications. However, the greater aesthetic appeal of other fonts and character sets will usually reward the designer who pays some attention to typography.

Special fonts are required for languages which use other than Latin characters, or applications which require special symbols, motifs, dingbats or other small illustrative devices. CD-I can display all these characters as bit-mapped fonts or images, like any other high-quality computer-based display system.

CREATING SPECIAL EFFECTS ON CD-I

The prospect of controlling special effects at the workstation is one of the most exciting features of the digital video environment for designers. In conventional film and video production, special effects are designed and recorded in the editing suites of a professional production facility. With CD-I and other digital platforms, designers can produce special effects as easily as any other feature under the computer's control.

CD-I makes particular use of its image planes to create visual effects on the screen. Thus, there is a technical distinction between those effected within one plane, and those which require both. A single plane can accommodate:

- Highlighting and lowlighting of individual objects or areas (for example, to draw attention to icons, or disable options which are temporarily inactive).
- Panning across or scrolling up and down a larger image.
- 'CLUT cycling' or 'palette switching', to create the illusion of movement in static diagrams by creating a stream of colour – for example, to indicate the direction in which information or energy flows, suggest the action of a pulse, or make objects appear to shimmer or sparkle.

With both Planes A and B, CD-I systems can support:

- Wipes, in which one image slides across the screen to replace another.
- Dissolves, in which one segment fades away as another materializes on the same screen (so that, in the middle of the effect, both images briefly appear superimposed one upon the other).

- Blinds, which blank out or superimpose alternate sub-screens to create the effect of a partially-opened Venetian blind.
- Irises, which typically expand from the centre of the screen (in a circular or other geometric shape).
- Mosaics, or granulation, which dissolve (in either direction) between a detailed photographic image and an abstract pattern of coloured blocks.
- Overlays, which employ chroma key (or colour key) techniques, or combine transparent mattes with opaque images.

Either or both planes may be used for:

- Cuts, the most familiar editing effect, in which the last frame of one segment is replaced directly by the first frame of the next.

The principles behind the use of the image planes, and the special effects which CD-I can support, are explained below.

Panning and scrolling

Large or complex images may be presented in a series of screens which effectively simulate the work of a rostrum camera by panning or scrolling slowly over an area larger than any single screen. In CD-I, an image up to four times the size of the full screen can be displayed this way (Fig. 7.15).

This facility was originally limited to fixed paths, back and forth, up and down. However, in 1992, New Media developed a means of allowing users to scroll freely in any direction over a large image. This innovation was first applied in *Salzburg*, a travel programme produced by Telemedia Germany; with scrolling maps, viewers can follow compass points, meander along a road or river, or simply slip from place to place as sites of interest appear on the screen. Hotspots scroll along with the maps so that interactive options are always available.

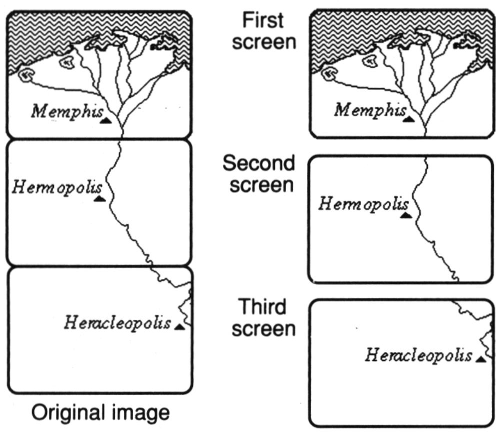


Figure 7.15: Scrolling

Cuts

Cuts are most obviously used to move directly from one scene or segment to another. A 'slide show' simply cuts from one still image to the next, at regular intervals, or under users' control. Cuts can be effected in a single image plane simply by encoding one image directly after another. Alternatively, the Display Control Program (introduced in the previous chapter) can instantly change the order in which the planes appear, so that one instantly replaces the other to fill the screen with a new image.

Of course, full-motion film or video are effectively no more than a long series of rapid cuts between still images, at rates of 24 to 30 frames a second. Moving pictures in CD-I can be created in a similar way, by effecting a series of rapid cuts between closely-graduated images. These are often presented within windows on the screen, at rates from full-motion down to 12 or 15 frames a second.

Transparency

As with other digital visual systems (including most computer graphics packages), images and colours on the CD-I image planes can be opaque or transparent.

- Opaque colours and images mask everything on the plane(s) behind them. The cursor, for example, is usually opaque so that it can easily be spotted anywhere on the screen.
- Transparent colours and images allow everything on the plane(s) behind them to show through. Partial transparency can be useful, for example, to add a tint of colour to a chart or drawing; total transparency is the basis of the chroma key effect described below.

This combination of free-standing opaque images in the foreground, and a separate (opaque) scene in the background is, of course, the foundation of the back projections and special effects so commonly used in films and television to simulate movement, height, depth or simply danger and excitement.

In conventional film and video production, this is the principle of the colour or chroma key technique, in which an image or scene shot against a neutral background (usually, a particular shade of blue) can then effectively 'lose' that backdrop, to be superimposed on another background altogether (Fig. 7.16).

This principle can be used in various ways to create special effects and to move gracefully from one scene to another. *Palm Springs Open* (described in Chapter 3, Multimedia Titles) visited 18 famous golf courses, shooting one hole at each to create

a dream course on CD-I. (It took a full day at each course to compile the 180 shots needed to cover all the potential 'points of view' at any one hole.) The courses were shot as landscapes, and two golfers were photographed separately as isolated figures in a blue screen studio, so that the two planes could be mixed interactively to cover all the options for two players on the 18-hole fantasy course, using chroma key techniques.

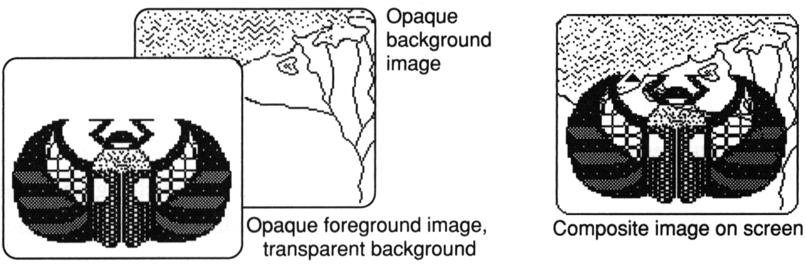


Figure 7.16: Chroma key

Chroma key used in this way offers one interim solution to the challenge of full-screen video. If the total area devoted to updating the chroma key figures can be kept within the constraints outlined in the explanation of moving pictures (page 201) – that is, within about 13 per cent of the ultimate screen area – moving video in Plane A can be laid against a static background in Plane B. This is a technique already used in many children's television programmes simply to create novel and diverting visual effects.

Mattes use similar techniques, effectively in reverse, to create a patch of transparency on the opaque screen, and use this to display (opaque) images from another source – which, in CD-I, is most likely to be another image plane. Mattes are, effectively, windows within the larger screen (Fig. 7.17).

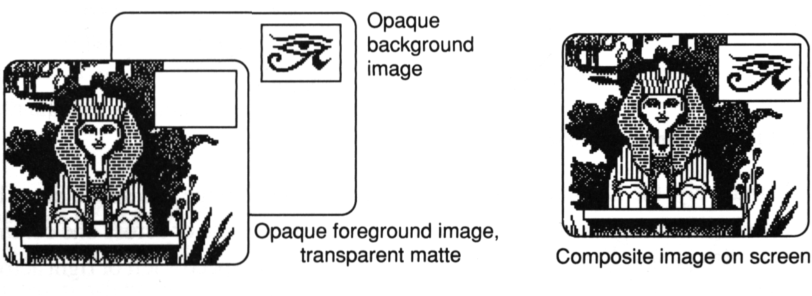


Figure 7.17: Mattes

Mattes can be of any shape or size, and can appear anywhere on the screen, singly or in combination. A series of mattes in graduated sizes could create the effect, for

example, of an image emerging in the shape of a star which starts as a pinpoint of light and grows to fill the screen. Mattes can overlap, to create layers of information from different sources. These effects are usually managed through the Display Control Program, which can distinguish between opaque and transparent pixels to create many effects with mattes and transparency.

Wipes

Wipes are effected by combining data from two separate images on one screen, so that one image replaces the other slowly enough that the viewer is aware of the change. With the use of transparency, both images can remain static and unchanging on their respective planes, while complementary pairs of mattes gradually cover the whole of the first image, and reveal the second (Fig. 7.18).

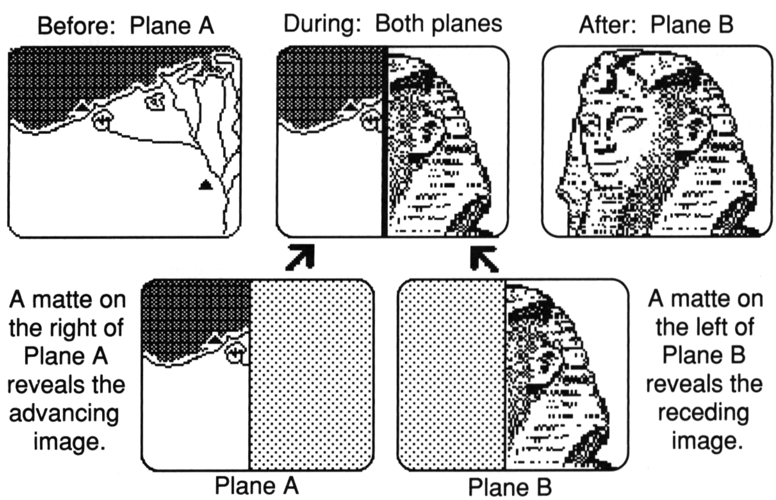


Figure 7.18: Wipe between two screens

Alternatively, the Display Control Program can effect a wipe in a single plane by transforming the image in the top plane, moving down one line or across one column at a time. Wipes can be effected in any direction and at any speed – left or right across the screen, up or down, quickly or slowly.

Dissolves and fades

CD-I can dissolve or fade one image into another by combining data from different image planes so that both appear briefly together before one replaces the other (Fig. 7.19).

Figure 7.19: Dissolve between two screens

- The brightness of any image can be adjusted through 64 levels from pure black (no intensity) to saturated colour (full intensity). The Display Control Program can control the image contribution factor of both planes independently, to increase one and decrease the other so that one image fades away as another emerges, or raise or lower both simultaneously. Intensity levels can also be adjusted within a single image so that certain parts appear to fade or emerge independently.
- With RGB 5:5:5, every 16-bit code has a 'transparency bit' which can be used to make that pixel invisible on the screen. This feature can be applied in dissolves to make the RGB image disappear; however, since RGB 5:5:5 occupies both central planes, A and B, the image which is left on the screen must come from the backdrop. This is the plane where full-motion full-screen video will appear, when that feature becomes fully functional; until this, the backdrop is limited to a fixed palette of 16 colours, or video from an external source other than the CD-I disc.

Another effect can also be used to deconstruct one image on the screen, and replace it with another – granulation, or mosaics.

Mosaics or granulation

Mosaics (or granulation) are now among the most familiar effects in documentary television, where the technique is often used to disguise the features of an interviewee whose identity must remain a secret. A confidential interview can be recorded under ordinary conditions, and re-processed to create blocks of shimmering patchwork around faces, bodies or any other visual clues which the producers wish to hide. With

a similar range of audio facilities to disguise voice patterns, digital editing techniques offer more anonymity to participants, and better audio-visual effects to producers, than earlier practices such as shooting under extreme lighting conditions.

Digital editing facilities offer two types of granulation, both of which reduce the resolution of the image by reducing the number of pixels on the screen. Where normal resolution calls for, say, a block of four pixels, double resolution uses eight, and high resolution uses sixteen, to create a more finely detailed image. At the other extreme, mosaic effects might use only one pixel where normal resolution would use many, to create a grainier image, with larger blocks of colour and less detail.

In normal resolution, each pixel position in a screen of digitally-encoded data is occupied by a separate 'picture element' (hence, 'pixel') which contains one tiny portion of the total visual record. Mosaic techniques effectively weed this garden of tiny seedlings, by selecting those which will be allowed to grow, and discarding the rest to make more room.

In 'pixel hold', the visual information in the selected pixel is held on the screen for a given number of pixel positions, replacing any data in the other pixels which originally held those positions. The hold factor can be anything from 1 to 255, and can be set independently for horizontal and vertical positions. Encoding instructions could dictate, for example, that the value of the first pixel in every block of six will be held for three positions horizontally, and two vertically. (In the example illustrated in Fig. 7.20, the first value in every group of four is held for two positions each way.)

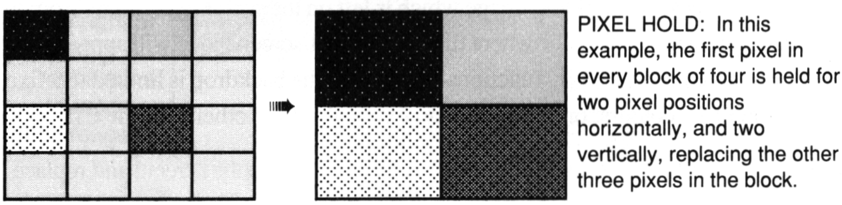


Figure 7.20: Pixel hold

'Pixel repeat' defines a block of pixels whose individual values are magnified to replace those of all the other pixels which follow within the defined area. (In the example in Fig. 7.21, the first four pixels in every block of 16 replace the values in the remaining 12 pixel positions.) A single pixel can only be repeated 2, 3, 8 or 16 times, so the range of effects from pixel repeat is limited.

The two techniques are used for different purposes, depending on the size and source of the original image.

PIXEL REPEAT: In this example, each pixel in the first block of four is magnified four times, replacing the 12 other pixels in the larger block of 16.

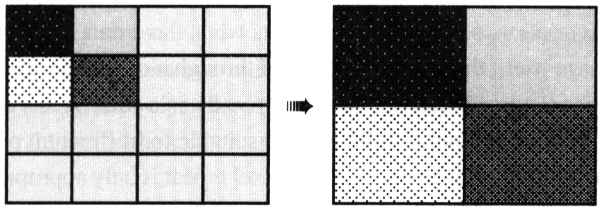
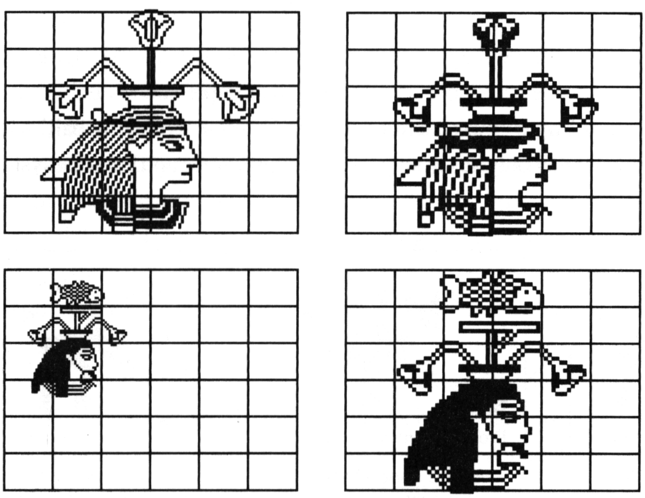


Figure 7.21: Pixel repeat

Pixel hold is used when the size of the image remains the same, but its resolution is reduced. This is the effect used to disguise an identity, by magnifying spots of colour to reduce a face to a block of flesh-tones. Equally, pixel hold can be applied in both directions – for example, in the transition between two scenes or images. As the hold factor increases, the first image is reduced to an abstract pattern of blocks; this is replaced, perhaps imperceptibly, by another abstract pattern, and the hold factor is reduced until a new image appears in normal resolution on the screen (Fig. 7.22).



With pixel hold, the size of the image remains the same, but the resolution is reduced. Pixel hold can be used on all types of CD-I images.

With pixel repeat, the image is magnified and resolution is reduced. Pixel repeat can only be used for static text and graphics.

Figure 7.22: Granulation through pixel hold and pixel repeat

Pixel repeat is used to magnify or zoom in on an image which has a limited amount of information to offer, and must be augmented to fill the screen. Typically, this might be an image which was recorded in low resolution in the first instance, or one which was designed to fill only a portion of the screen. A small image which was encoded

to fill only a quarter of the screen at normal resolution needs four times as much information to fill the entire screen; when those data are not in the pixel values of the image itself, they must be supplied through a decompression technique such as pixel repeat.

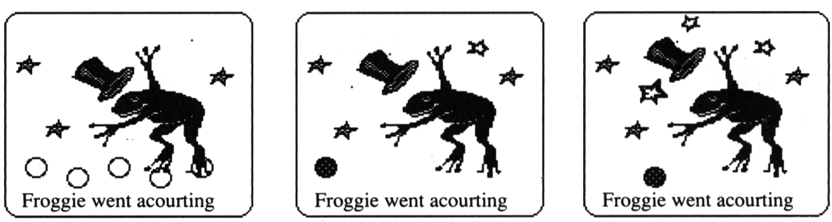
The two granulation effects are suitable for different types of images – pixel hold can be applied to any source, but pixel repeat is only appropriate for text and graphics:

- Pixel hold can be used with any CD-I image encoding technique – DYUV, RGB 5:5:5, CLUT or RLE at any resolution.
- Pixel repeat can only be used with RGB 5:5:5 and CLUT – that is, not with photographic images encoded in DYUV, nor with animation which uses run-length encoding.

The use of all these techniques can easily be enhanced by the creative deployment of colour and the simulation of movement through CLUT cycling.

CLUT cycling

Movement is the most basic and engaging technique available to screen designers, and rapid colour changes alone can produce some technically simple and visually-striking animated effects. One example of this technique is the familiar 'bouncing ball' which often accompanies the display of lyrics in sing-along programmes and karaoke systems (Fig. 7.23).



Five transparent circles set the positions for the bouncing ball | As the song starts, the first ball fills with colour | The ball appears to bounce as the colour fills each shape in turn

Figure 7.23: Using CLUT encoding to simulate animation

In this example, five circular shapes define all the possible positions for the ball on the sub-screen. When the balls are the same colour as the background, they are effectively invisible; however, as each in turn is briefly filled with another colour from

the look-up table, the ball appears to bounce across the screen in time with music. CLUT locations may be drawn from one table, or from different tables in succession (the 'palette switching' of graphics paint packages).

Partial-screen updates can be used elsewhere on the same screen (for example, to throw Froggie's topper in the air, and add stars around him).

INTERLEAVING AUDIO AND VIDEO

The previous chapter explained how data from the CD-I disc flows through the system in a steady stream, which must be carefully regulated to ensure that all audio-visual and other data reaches the right part of the system at the right time, and in the right order. To achieve this, data must be efficiently arranged on the disc, in the sectors which represent the smallest discrete units of information handled by the CD-I system.

Audio data set the pace for all associated material, since audio sectors must be laid down strictly in order (Fig. 6.4). For Level C mono, for example, the audio data for any one soundtrack must be recorded in every sixteenth sector, and nowhere else. Where there is more than one track, the sectors for each may be recorded near one another, but must still maintain an absolutely consistent internal pattern. Thus, in any block of 16 sectors, one may be devoted to Track A, and another to Track B, but each sector in each track is still exactly the same distance from the last and next sectors in the same track. It is this strict pattern which allows the system ultimately to deinterleave all these various data, and sort the different audio signals into separate, coherent soundtracks.

After the audio is accommodated, the remaining sectors are free for video or program-related data such as text and hotspots. During a picture essay, which combines still frames with music or narration, the images are treated as individual graphics, and their delivery to the screen is controlled by a sequence editor, which typically uses time codes to ensure that each graphic appears in order, and is held on the screen for the appropriate length of time. The calculations are relatively straightforward, as single images do not demand an undue proportion of the data channel.

When moving footage is involved, a more complex equation calculates the amount of space available for video footage once the audio sectors have been accommodated and, given the encoding method and rate of frames per second, the size of window which these data will support.

The data for each video image must occupy an integral number of sectors (that is, a whole number rather than a fraction), since the sector is the smallest unit of data

processed within the CD-I system, and is either filled or not filled. Data which requires, say, 3.65 sectors will be effectively 'rounded up' and assigned to four whole sectors.

This integral number can be calculated according to a relatively simple formula:

$$Ns = \text{Int}\,[(16 - As) \times 75 \,/\, 16 \,/\, fps]$$

Where:

- *Ns* represents the number of sectors available for each frame.
- Int represents the integer (or result expressed as a whole number, in this case rounded up to the nearest whole).
- *As* represents the number of sectors devoted to audio in every group of 16.
- *fps* represents the number of frames per second.

This calculation determines:

- The number of sectors available to video data, after the audio data have been accommodated. The number of sectors required for the audio, subtracted from the 16 in the group, leaves the number available for video (i.e. '16 – *As*').
- Then, the total number of video sectors passing through the system in one second, which is calculated by multiplying the number of video sectors by 75 (the data transfer rate) and dividing this by 16 (the total number of sectors in a group).
- Dividing this result by the chosen number of frames per second determines how many sectors are available for each frame in a second's worth of video.
- Because the video data must occupy an integral number of sectors, the final result is rounded up to the nearest whole number.

For a segment with Level C audio (which occupies one frame in every group of 16), and a frame rate of 12.5 per second, the equation would be:

$$Ns = \text{Int}\,[(16 - 1) \times 75 \,/\, 16 \,/\, 12.5]$$
$$Ns = \text{Int}\,(15 \times 75 \,/\, 16 \,/\, 12.5)$$
$$Ns = \text{Int}\,(1125 \,/\, 16 \,/\, 12.5)$$
$$Ns = \text{Int}\,(70.3125 \,/\, 12.5)$$
$$Ns = \text{Int}\,(5.625)$$
$$Ns = 6 \text{ sectors per frame}$$

Every sector in Form 2 (in which video is encoded) contains 2324 bytes of actual data. Thus, six sectors afford 11 620 bytes altogether for the video data. The table below summarizes the results of this equation with audio at various levels, mono and stereo.

Since the results are rounded off, in this example there is no material advantage in using audio of the lowest quality (Level C mono) when higher quality Level B mono, or Level C stereo, effectively occupy the same space to better account – a valuable discovery to make at an early stage of the design process (Fig. 7.24).

Audio Level	Audio sectors per 16	Bytes per frame PAL/SECAM @ 12.5 fps	Bytes per frame NTSC @ 15 fps
Level A stereo	8	6972	4648
Level A mono	4	9296	6972
Level B stereo	4	9296	6972
Level B mono	2	11 620	9296
Level C stereo	2	11 620	9296
Level C mono	1	11 620	9296

Figure 7.24: Bytes per frame at 12.5 and 15 fps, and various audio levels

The final stage in the equation for partial-motion video is to determine the size of window which any given quantity of data will support.

- Video is typically encoded in DYUV, the best format for photographic images, which requires one byte per pixel.
- The whole PAL/SECAM screen, at normal resolution, contains 384x280 pixels, or 107 520 pixels altogether (80 000 in the safe area); an NTSC screen at normal resolution contains 384x240 pixels, or 92 160 altogether (67 200 in the safe area).
- In this example, the maximum 11 620 bytes available for PAL/SECAM video represents 10.8 per cent of the 107 520 bytes in a full screen at normal resolution, or 14.5 per cent of the safe area of 80 000 bytes.
- In NTSC, given the slightly different screen size and faster frame rate, the window of 9296 bytes would be slightly smaller, at 10.1 per cent of the total area, or 13.8 per cent of the safe area.

Thus, this combination of data in PAL/SECAM would support moving pictures at a rate of 12.5 frames per second in a window occupying about one-ninth of the total screen (or just under one-seventh of the safe area) with a choice of Level B mono or Level C stereo sound. In NTSC, under comparable conditions, the window would occupy one-tenth of the whole screen, or just over one-seventh of the safe area.

- To enlarge these windows, Philips have developed a further stage of data compression for moving video, called UVLO (i.e. low resolution U and V, or UV-Low), which produces slightly grainier pictures, but increases the window by half. Under the same conditions, with UVLO encoding, the PAL/SECAM window fills 16.2 per cent of the total screen (21.8 per cent of the safe area), and the NTSC window fills 15.1 per cent of the total screen (20.8 per cent of the safe area).
- Vertical interpolation (UVLO+), which employs alternate images to supply the even and odd lines of the television display, can effectively double even UVLO encoding, to make the window 32.4 per cent of the PAL/SECAM screen, or 30.2 per cent of the NTSC screen. However, these images can be unsteady and, unless very carefully designed and executed to minimize contrast, present pictures of poor quality even by comparison to VHS videotape.
- For all these encoding methods, when the analogue video source is digitized and edited for the CD-I display, the horizontal dimension must be a multiple of four pixels; where vertical interpolation is employed, the vertical dimension must be an even number (to support interlacing on the television).

These calculations, and the consequences of the trade-offs which they represent, clearly illustrate why it is essential to build and emulate a CD-I application as it develops, to ensure that all these data are providing the right quality and quantity of information, and have been interleaved correctly to support a seamless and synchronized presentation.

The numbers game

John Ramo, President of Sonic Images, who produced *Children's Musical Theatre* and the *Private Lessons Series*, emphasizes that 'Designers and creators of this new language of multimedia ... must always seek to empower the user [and] must give the user feedback wherever possible. Dialogue is a basic human propensity that needs to be creatively addressed as we discover just what this medium is capable of.'[1]

The technical consequences of this are not lost on experienced producers such as Ramo. He notes that one song in *Children's Musical Theatre* – where users can change one key word in each of nine lines – represents 3^9 or 19 683 possible combinations of data even when the change is restricted to a choice of three options in each of nine lines. In the first line, for example, the choice lies between a boat, a train, and a plane, so the line may read: 'If I had a boat I'd sail away', 'If I had a train I'd drive away' or 'If I had a plane I'd fly away'. Screen text has to be supplied for each version, and all three lines must be separately recorded on the audio track.

By producing text and audio for three variations in each of the nine lines, the song is effectively contained within 27 discrete units, which can be variously combined by the user. However, even this required some strategy to provide the song at Level B audio (which fills 25 per cent of the bandwidth) and keep animation moving on the screen at a rate of eight frames per second.

Sonic Images' production team had originally to work with the .99 version of the CD-I player, for which they devised their own buffer schema to disguise unacceptably long seek times by storing data in RAM, and using multi-tasking to produce the final presentation in real-time. Fortunately, the *Green Book* was modified subsequently to facilitate one-second seeks within 40MB, and individual song lines of not less than five seconds.

In *Children's Musical Theatre*, the equation is further complicated by the choice of three musical styles for every song – classical, pop, and country – each of which has to be arranged and delivered within a specific time, to facilitate the even flow of data through the system. The producers found that the individual song 'units' had to be recorded as a group, and could not be interleaved to optimize the storage capacity of the CD-I disc, which effectively restricted them to a little over an hour's worth of solid recording.

The *Children's Musical Theatre* includes a paintbox, so users can create their own colour schemes for characters and backgrounds in the songs, and see these animated on the screen. As well as this 'Songmaster' mode, the disc also supports linear presentation, a karaoke version for singing along, and a 'music-minus-one' variation to alter the arrangement or play along at home. It's good fun, but a far cry from the marketing hype of limitless interactivity on a single CD. A powerful calculator is a valuable design tool, for it can be sobering to discover what the simplest interactions can demand in technical and creative support.

WATCHING TV

Clearly, compact disc formats pose many creative, aesthetic and technical demands to create programmes which are intellectually and visually satisfying to audiences thoroughly familiar with the conventions of film and television. The irony for the interactive multimedia designer, juggling all these equations, is that some of the best modern television design strives to create the very effects which some CD-I designers regard as constraints.

Certainly Britain's most interesting documentary, news magazine and pop music programmes now make extensive use of small windows to contain talking heads and moving footage on the screen, split screens which combine archival photos with modern footage, the use of slow motion to extend a video clip to fit a longer audio quote, partial updates, text and graphic overlays on still and moving video, and even the grainy images and painterly colour effects of digital image processing. Television at this level offers a good many excellent ideas and models for designers who are new to these conventions – and some comfort to the production team who have struggled to overcome the constraints of the digital production environment, only to see television producers spend small fortunes in the editing suite, deliberately to create the same effects.

Note

1 John Ramo, Sonic Images, speaking at the Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.

8

The production team

This chapter describes the tasks and responsibilities common to any interactive multimedia project, and the particular demands of CD-I. It also addresses the preparatory stages typical of any project, as an introduction to the specific activity described in the next chapter.

LEARNING FROM EXPERIENCE

With computer-based training, and even with interactive video, for better or worse, one person can write, design and execute an entire package single-handedly. With CD-I, the development process tends to be a collaborative venture which draws on the skills of many specialists.

The term 'authoring' in CBT and IV often describes tasks associated only with computer programming but – in all interactive platforms – authoring truly embraces a much larger creative activity. In CD-I and other multimedia environments, virtually all tasks are interdependent, and authoring could describe the entire production process. The process is necessarily linear, beginning with an empty canvas and leading by stages to a complex and varied multimedia programme. But it is also highly iterative, with many rounds of simulation and testing, where virtually every change to content or structure initiates a round of complementary activity to bring other elements in line with new features and ideas.

The first generation of IV programme-makers was drawn largely from people with experience in television, corporate video and computing, the crafts whose tools were brought together in the first interactive video systems. Some of these were consummate communicators, who could write a script, supervise production and complete the

whole project on schedule and within budget. Others at least knew where their own strengths lay, and where to find skills which complemented their own. In the early eighties, some people made programmes which look good today, on systems which demanded as much technical as intellectual creativity.

However, many other programmes (then and now) proved to be little more than 'interrupted video' or 'many media' – corporate videos that remain essentially linear in structure, or computer-based training with a few sound effects and pictures. An interactive computer program with some linear video tacked on one end, or a game that displays a slow succession of decorative pictures while the audio track carries the story, hardly represent multimedia at its best.

It soon became apparent that many, quite different, skills are needed to design effective interactive presentations with the best possible text and graphics, sound and pictures, structure and content. The IV industry discovered that whole disciplines existed to observe, analyse and apply principles of instructional design and learning theory. The next wave of designers included many teachers and trainers – professionals who understood how to foster learning.

At the same time, IV began to value specialists whose creative and practical skills were already recognized in other media – graphic artists, scriptwriters and project managers. Developers also realized that special talents were required to apply conventional production techniques to new environments, and that some entirely new skills were emerging to meet the demands of interactivity. A few organizations initiated in-house training schemes, and seminars or courses for other companies. By the early nineties, most developers are calling for more training and recruitment, and there is a real shortage of creative and technical staff with the skill and experience to produce fully interactive multimedia programmes.

THE PRODUCTION TEAM

Even in multimedia platforms such as CD-I and CDTV, some projects have been created largely by one person with a strong vision, a variety of skills, and access to specialist services. However, most projects require more human resources, both to accomplish the volume of work involved, and to bring skills and experience to creative and technical jobs. A team of specialists, working co-operatively, can place every job where it is most likely to be done well and quickly. With good management, team spirit is one of the most valuable assets a publisher can enjoy.

Equally, a team in itself is a rich source of diverse ideas, perceptions, opinions and experience. Variety is the strongest argument for mixing and matching teams between projects, and combining the experience of full-time staff with the stimulus of freelancers and consultants.

The content of any one programme will influence the balance of skills on the production team. A highly-visual game packed with original graphics may call for a team of visual designers, plus one good all-rounder to write both the script and program. Some familiar production roles may only be filled in projects which specifically demand, for example, researchers, content experts or video directors.

One person may fulfil more than one role within any production team: it is not unusual, for example, for the producer or content expert to write the script. Yet there is a strong argument for respecting the skills of specialists, even if this means hiring a freelancer to take on a particular job such as writing or directing. Good all-rounders can often do the job, but dedicated professionals usually do it that much better, and the difference can represent the real added value of the finished product. However the responsibilities are eventually assigned within any one project, the roles to be fulfilled in a typical multimedia production team are described in the pages which follow.

Producer or creative director

A producer or creative director, in large projects at least, formally assumes responsibility for both content and structure, as well as the administration and execution of the project as a whole, and often takes an active role in the instructional and visual design of the work.

Orchestral metaphors are popular here – the producer is often compared to a conductor, who has to understand music theory, administration, the make-up of this particular group of players, and the score itself. Producers, like conductors, may also be conscious of the reputation of their orchestra, the expectations of their audience, and the demands of working with guest soloists.

Philip Mittelman, President of CD-I Systems, believes that 'the most important task for a producer is to create and nourish a team of talented people'.[1] John Gray, President of Capitol Disc Interactive, says, 'Productivity depends totally on the motivation of individuals within the team. I have no scientific data, but experience tells me that it can vary by two to three hundred per cent. Successful motivation relies on matching projects to teams, and rewards to goals.'[2] Gray suggests that, once the creative and instructional design has been established, the producer should assume an administrative

and supervisory function, and allow the technical director, title engineer or head of programming to build the package within the constraints of the platform. Linda Delaney of Capitol Disc Interactive says, 'Although my business card says that I'm a producer, that's really a fancy way of saying I'm a project manager. There are no cowboys in CD-I – it takes a team.'[3] (John Gray recommends 'only one strongly creative person in each team, to avoid the duelling ego syndrome'.)

Project manager

A project manager often fills the producer's administrative role in a project where the creative director is in ultimate control.

The project manager often acts as the orchestra administrator, who is expected to know a good deal about music without necessarily being a player, and to understand budgets and schedules, as well as personnel and team management. In multimedia production, the project manager has tended to be a player as well, and to be closely involved with every stage of the project. However, with the move from corporate video to electronic publishing – from one-off IV commissions to a series of titles for the consumer market – project, studio and network management are emerging as separate administrative positions.

There has been a trend in the corporate market for interactive video for clients to provide their own project managers, even where most of the work is supplied by a single production company. This is often a stage on the learning curve for companies who have been guided through earlier projects by experienced production companies. It certainly represents a full-time job for the project manager for the duration of the project, although this may be set against the value of accruing expertise in-house, and controlling both budgets and schedules directly.

Content specialist

Subject expert, adviser, consultant or researcher – the actual demands of any one programme will determine what information is needed, and who can supply it. The researcher may do as much as the orchestra's librarian, acting on instructions to find specific information, while a consultant may have the authority of a musicologist with a comprehensive view of a specialized subject.

If an entertainment title requires consultancy, it may be to learn more about similar products in the market, perhaps from a journalist who regularly covers this field.

Equally, a researcher might provide this information from desk research, interviews with users and producers, and visits to shops, exhibitions and conferences – techniques which might also be employed in the preparation of a training programme or reference work. Generally, a subject researcher will provide data for the content of the programme, while a picture researcher specifically identifies sources of visual material (usually, through picture libraries and archives).

A reference work may also benefit from the knowledge and endorsement of a recognized expert. In publishing, the researcher's first job may be to identify the higher authority who will be invited to take this role. In a bespoke commission, particularly in training, the content adviser usually comes from the client company, to liaise between the production company and the client organization, and even to act as the project manager. The consultant may work as a full member of the production team, or simply be on call to answer questions as they arise.

This researcher or consultant may write the script, at least in draft form, and is often involved with later phases of the programme, to ensure that the original research is not distorted or misinterpreted during production. The subject expert should certainly participate in at least one round of testing and evaluation, specifically to watch for errors of fact or interpretation which may inadvertently have crept in during the later phases of the project.

Instructional designer

An instructional designer ultimately determines the content and structure of the programme, often working closely with specialists such as content experts, researchers and writers. The instructional designer is something of an orchestrator, who shapes raw material into a detailed document which provides everyone with an overview of the entire work, and specific instructions for their part of it.

The instructional designer may undertake the research, and write the script as well. But the core of instructional design is the structure of the programme, which determines how information is presented, and the range of interactive options which will be available. Typically, this is presented in a preliminary design document which combines simple flowcharts with a description of the programme in succinct prose. Detailed design comes later, to specify the precise content of every individual segment, and all the possible interactions between them, and their consequences. (Instructional design is discussed more fully in Chapter 5, Designing for Interactivity.)

Scriptwriter

The scriptwriter in multimedia production acts rather like the composer within a theatre company, whose creativity must flourish within very strict parameters. Both are expected to understand the technical demands of their environment, and to execute instructions provided by those who control the project as a whole.

Nonetheless, the scriptwriter may work closely with other members of the team, and provide essential creative ideas. Writers, particularly, understand metaphor (often, better than conventional graphic designers) and often have strong visual imagination, even where their technical skills are verbal. It is important to remember that writing is as broad a field as designing, and that good dialogue particularly demands a special order of skills. It is not unusual to combine the skills of the content expert for segments with technical content, and a professional scriptwriter for dramatic sequences, introductory and general material.

The writer, too, may be involved in later stages – for example, at the video shoot, where dialogue is often amended in the course of production. The writer should also see at least the penultimate version of the completed programme, to ensure that the script has been accurately, or at least faithfully, interpreted. (Practical aspects of screenwriting are discussed in Chapter 10, Screen Design.)

Graphic designer

Designers, too, have a similar role in multimedia as in the theatre, for their influence varies according to the structure of the team, and the nature of the project. The graphic designer may be responsible for visual style and conventions as well as the content of specific still images. Equally, the creative director may establish the visual criteria, and instruct the graphic designer to execute individual screens according to the data provided in the script and detailed design documents.

Multimedia designers may create conventional flat artwork or computer graphics (including animation) from scratch or work with a variety of material from diverse sources, all of which is digitized as computer data and then adapted for the screen. Screen design is a discipline in itself, with some strict rules dictated by the shape of the screen, the composition of the visual signal, and any number of aesthetic conventions, some of which change almost seasonally to reflect contemporary taste. Multimedia production simply adds another layer of technical constraints and possibilities.

Designers with a background in television, video or computer games understand the basic conventions. They may also be more sensitive to fashion than other members of

the team: broadcast television here reflects the subtlest trends in screen design, which makes TV both a good source of ideas but an unstable model for a programme with any shelf-life. A designer is usually also an artist with a personal style or repertoire, or a specialism such as the design of text screens or illustrations for fantasy games, so one team may include designers with complementary skills, styles and interests. The specific tasks associated with graphic design in CD-I are described in the next chapter.

Audio-visual producer

The audio-visual producer or designer, within the multimedia team, is usually responsible specifically for the execution of footage from video, film or even a motorized photo camera. Conventional 'cartoon style' animation is usually created with the computer software of the graphic design team, although some forms of three-dimensional animation (with malleable figures, for example, or puppets) may be separately commissioned from specialists.

Conventional AV production necessarily combines sound and pictures, either recorded simultaneously or only mixed in the editing suite. In multimedia, all audio is necessarily stored and processed separately even from the video which it accompanies, and different technical standards govern the preparation of sound and pictures. Until full-motion, full-screen video is effectively integrated into multimedia platforms, the combination of narration, music and sound effects with graphics and animation will be more visually- and cost-effective than conventional video treatments.

For those with a background in film, corporate video or television, this represents a significant change in emphasis, as well as a new order of technical considerations. A video producer with a background in tape/slide production may be more valuable than a TV or corporate video specialist to the CD-I team. Yet where some form of video is employed, a video producer with a thorough understanding of the conventional medium should make best use of moving images in the new medium. Where original footage is required, the producer manages the shoot like any corporate video project, supplementing in-house resources with external suppliers to provide, for example, a production assistant (PA), camera crew, editors and post-production facilities.

Programmer

Programming in multimedia environments is virtually a watching brief, for new tools and products are changing the demands of the job, and providing programmers in CD-I

with resources similar to those which the authors of CBT and IV programs already enjoy.

Programming in any compact disc format initially meant writing in general-purpose computer languages such as C, occasionally assisted by such software tools and routines as any one organization might develop for its own use. Many proprietary products exist to help programmers working on computer-based training or interactive video applications, but it was only in the early nineties that versions of these, or new products similar to them, began to be developed for CD-I and other compact disc platforms.

Programmers can now draw on some hardware and software tools and libraries of standard code to execute common functions. Most companies with production experience also have their own repertoire of reusable codes and techniques. However, programming in this environment demands a solid foundation on which to build new skills – typically, experience with a popular programming language (specifically, C), and some understanding of the OS-9 operating system on which CD-I's CD-RTOS operating system is based.

Typical users

Multimedia development is highly iterative, and most designers and programmers constantly test and evaluate their work as it progresses. However, it is important that the whole application also be tested at regular intervals by people who are not intimately involved with the production at this stage. 'Naive users' are a sub-set of external suppliers, who often have to be recruited (and are sometimes even modestly remunerated for their services).

Initially, work in progress may be tested by other members of the team (such as the researcher and content expert, for example) or colleagues within the organization. Eventually, though, it should also be tried by real users, selected where possible from the target audience. In a corporate commission, the client should be able to recruit typical users for this exercise. In practice, friends and family are often pressed into service (although their 'naivety' may be doubtful). Field tests can also be organized in co-operation with local schools, colleges or community centres. It is not unknown to waylay likely-looking passers-by in the nearest shopping precinct; however, a *bona fide* market research company is better equipped, legally and professionally, to do this legitimately and recruit a proper sample according to the criteria which define the target audience.

Although most guinea pigs appreciate some assistance in getting started, and the assurance that help is always close to hand, observation tends to make even experienced users uneasy. A questionnaire is a practical alternative, and built-in management software both can monitor users' performance uniformly and analyse the results. Users may complete the questionnaire as they go along, or after they have viewed the programme, or it might be used by a researcher in a structured discussion with users. It is often illuminating to gather a little personal information about users' background and experience, to analyse their reaction to the programme; again, some experience of market research may help here. (A typical field trial of this kind is described in the case history in Chapter 12.)

Training the production team

It is essential that designers who have never worked with interactive media begin by learning about interactivity and the nature of communications between people and machines. This typically begins by reading books, trade magazines, academic journals and professional newsletters; it should also involve visits to exhibitions and conferences, and hands-on experience with a variety of systems and programmes (including training material, public information programmes, marketing presentation and games). A visit to an amusement arcade with lots of video games can be instructive, although novices may find it more profitable to concentrate on watching skilled players – play-as-you-learn can be a very expensive exercise.

Equally, designers whose idea of interactivity is informed by years of work with computer-based training, games or interactive video, may benefit from a fresh perspective on a market now influenced by emerging technologies from interactive television to virtual reality. Much of the interactive programming of the eighties was confined by the technical limitations of the delivery systems, and the inexperience of everyone involved in this very new market. The multimedia systems of the nineties often employ radically different approaches to interactive communications. Even experienced designers should occasionally pause to think, analytically and creatively, about the nature of the interactive communication process, and the experience which they are offering to others.

A number of companies and institutions are beginning to offer formal training in interactive multimedia skills, and CD-I in particular. These include:

- Philips, whose courses include a Technical Overview for anyone interested in CD-I, a Designer's Foundation Course for designers with experience of other

interactive media, and a Programmer's Foundation Course (ideally, for programmers with experience of UNIX or OS-9).

- The companies which supply the CBT, IV and multimedia markets, who usually provide training courses specifically on their own products, but naturally incorporate a good deal of theory, and provide many examples of good and bad design and programming.
- Institutions such as Birkbeck College, University of London, which offers extramural certificate and diploma courses in interactive technology.

Philips have also established CD-I studios in strategic sites, to provide samples of programmes and products as well as information services, technical advice and consultancy. A number of these information and technical services are available on subscription, for those simply watching the market, as well as active CD-I developers. (See Appendix 6 for addresses of principal Philips' offices.)

INTERNAL AND EXTERNAL RESOURCES

Some developers with a serious commitment to CD-I have already established their own production studios. Others, on a smaller scale, are developing titles with one or more workstations in-house, and taking any large or specialized jobs to external suppliers. (Similarly, many organizations which produce corporate video will maintain a small off-line edit suite in-house, to prepare rough cuts in their own time, and then turn to a professional production facility for the much more expensive on-line editing equipment needed to produce the final video.)

Access to at least some production facilities in-house will encourage the research and development necessary to mount the steep learning curve which new multimedia platforms present. How much of any one project is completed in-house, and where even dedicated CD-I producers turn to external facilities, is very much a matter of individual resources.

The emergence of new productivity tools, such as the Image and Audio Conversion package described in the next chapter and those described in Chapter 11, Programming, are providing CD-I developers with the hardware and software to accomplish work in-house which formerly might have been consigned to external suppliers. The jobs which any one organization may undertake depend on a variety of factors from capital investment in new hardware to the cost of recruiting or training operators and upgrading software.

In virtually all media, from books to videotapes, certain activities which require special skills or expensive equipment are consigned to suppliers with the appropriate resources. In CD-I, for example, moving video footage is now always sent away for processing, and most developers also use external facilities to process at least some audio material. It is simply beyond the scope of any one producer to provide the capital investment, and maintain the equipment and operators necessary for such specialized tasks. At the same time, write-once check discs may equally be commissioned from external suppliers, or produced in-house if the volume of work, or questions of confidentiality, justify the expenditure on hardware, maintenance and training. The sections below raise some of the questions to be considered in defining the scope of any one company's activities.

Creative and technical staff

Ultimately, control must always rest with the core team, even if freelancers or external suppliers provide some technical and creative services. The in-house team may have considerable expertise and still commission specialists for particular services.

Outsiders can add real value to a project simply by introducing new ideas, practices and techniques – stimuli which may be lacking in a team that has been working together too long, or too closely on one project to see the wood for the trees. Freelancers and consultants can also supply skills and expertise which may reflect years of training and experience. In disciplines which require considerable creative and technical finesse, it is often cheaper and easier to hire people who are already well up the learning curve.

However, many people with creative or technical talents are simply not attracted to full-time employment in one environment (particularly, to working within the production facility of a large organization primarily devoted to some other activity, such as the AV unit of a financial institution). The interactive multimedia market is particularly competitive, as there are not yet nearly enough people with the requisite experience in these new platforms. Qualified staff will be attracted by good salaries and working conditions, as well as the promise of professional development in a creative environment, but some skilled practitioners may only be willing to work on short-term contracts. (For this reason alone, it is particularly important to ensure confidentiality and copyright agreements with freelancers who may go on to work for your competitors.)

If it is advantageous to develop new skills in-house, a qualified freelancer can help employees to learn on the job. It is easier to be honest about this from the outset, both

to pay the consultant a premium for passing on these skills (or even providing formal training), and to allow for the extra time in the production schedule which this professional development process will necessitate.

Either way, it is essential to set realistic budgets and targets (and contingency plans) before agreeing fees or rates of pay with freelancers and other external suppliers. If the project runs significantly over schedule, there may be problems re-negotiating the contract, or even securing the services of people who are already committed to other jobs. Equally, over-running often means overtime or extra days at agreed rates which can put a project over budget as quickly as any element in the entire production process.

Although most of this discussion concerns the people who actually design, create and produce the multimedia programme, it is also important to consider the value of professional skills in choosing presenters, actors and narrators. It may be tempting to use local talent – for the subject expert to present the programme, perhaps, or find a colleague with a good baritone to supply the voice-overs – but the difference between trained and experienced performers, and gifted amateurs, is only too easy to spot on screen. Television has many gifted presenters who first gained recognition in other professions, but it is only because they have since gained the skills of a professional broadcaster that we see the TV doctor performing so well before the camera.

It is striking, by comparison to archival footage of a decade or two ago, how well people in the street or the studio audience now present themselves to the camera – certainly, there are many places where the spontaneous reaction of 'real people' can be more effective than scripted commentary or dramatizations. However, scripts are professional documents which benefit immeasurably from the gifts and skills of professional performers. A weak script can be saved by a good reading, but a good script can turn to ashes in the mouth of a dull speaker. A relaxed, conversational style is always engaging, and a trained broadcaster can deliver virtually any script with the right balance and tone for its subject and audience.

Production facilities

An in-house production facility demands material investment in hardware, software, media and accessories, as well as maintenance and upgrades, even without considering the cost of hiring, training or upgrading qualified operators. This must be justified by the volume of work or special considerations such as the need for absolute confidentiality. The investment must also ensure that the facility can supply work of the appropriate quality – economies of scale are vital here. The hire of external facilities,

on the other hand, always includes a premium to cover their overheads and related expenses. Equally, when any technology is very new, no one knows much about it, and hiring external suppliers to learn alongside your own team is effectively paying for someone else's on-the-job training.

Essentially technical activities such as digitizing and encoding can usually be entrusted to dedicated production facilities, providing of course that the production team supply explicit instructions for the work which they are commissioning. However, in most cases, activities which are vulnerable to subjective judgements (such as image capture or graphic design) require close personal supervision, whether they be executed in-house or at an external facility.

A production company can sometimes bring more weight to bear on outside suppliers than its own employees, particularly in demanding more or better service, or tighter cost control – questions of morale and internal politics sometimes render in-house negotiations more volatile than external contracts. The external supplier may also be able to hire or re-allocate resources more easily than the client. As a final resort, unhappy clients can always take their business elsewhere; however, pitting suppliers against one another in endless competition has proved a bad move in the long run in the interactive video industry, which has suffered from a significant lack of long-term relationships between clients and suppliers at every level in the food chain.

In calculating the cost of in-house production, or the value of external services, it is important to remember that the capital cost of hardware is only a part of the equation which also includes expenses such as office overheads (not forgetting administration), labour and all the costs associated with being an employer, insurance, depreciation, maintenance, and the periodic upgrades which software and hardware inevitably demand. The difference between hire and purchase, too, may have consequences for the annual accounts, for these funds come from separate budgets and can be written off in different ways.

Ultimately, one of the incalculable benefits of the fully equipped in-house studio is simply convenience. At New Media, for example, images of all kinds can be captured in a studio which is immediately next door to the CD-I designers' workstations, and networked to them for instant, direct communication. Any experienced designer or producer can attest to the value in time and money of being able to effect changes, corrections and amendments quickly in-house rather than sending material back and forth between external facilities, with all the additional time, expense, administration and risk which that involves.

EXPLAINING INTERACTIVITY

In any technology-based project, it is essential that everyone who makes creative decisions understands at least in general terms both the technical potential and current constraints of the platform. Obviously, the key members of any production team must be trained and should have some relevant experience. Multimedia production requires endless trade-offs between form and content, and it is essential that designers appreciate that they have a technical as well as a financial budget. The choice of still and moving pictures, photographs and computer graphics, dramas and simulations, has to be reckoned in megabytes as well as money.

However, it is equally important that everyone else – from video editors to voice-over artists – understands how interactive communications differ from linear models. To attain the range of technical skills demanded by the newest multimedia systems is to scrabble up a stony slope. To grasp the concept of interactivity, and the effect this has on the structure of a recorded programme, is a short leap over a deep chasm.

This became obvious in briefing actors, who are often familiar with the constraints of corporate video but who, without explanation, do not necessarily understand why interactive video appears to require several versions of the same short scene. What seems like a re-take for corporate video is often a critically different scene in IV. The challenge for performers is to keep the delivery fresh and the character consistent in every scene, without knowing precisely what any one viewer might ultimately see.

It is of course helpful to give performers some idea of the structure of the programme, to identify scenes which all or most users will see, or paths which guarantee that some segments will always appear before or after others. It is likely that, in a training programme for example, any one person may find perhaps a third of the information available, but all users will see the same core of essential information. In a game, a dedicated player will probably find every scene, but perhaps only after weeks or months of investigation.

The challenges facing the performer are only a fraction of those facing the writer: this is why interactive presentations tend to be developed iteratively, and to benefit greatly from cold testing by new users at regular intervals. In instructional writing of all kinds, it is useful to reiterate key points in sections which might be read in isolation, or where the reader may have forgotten ideas raised much earlier. With interactivity, it is imperative to test every possible option to ensure that the essential information reaches every user, in a way which appears logical within the context of each individual approach to the information.

This is the challenge which faces every member of the interactive multimedia production team. Users may approach information in many different ways – some like to pursue a direct line of enquiry, others like to explore – but a good interactive design will support this range of learning styles, and still ensure that every user receives the same essential information. It will also ensure that every path through the material maintains an internal logic.

This is less challenging in television and video: so long as the production team presents a coherent argument, most viewers will grasp the information even if they might have preferred a different presentation. In print, readers can pursue the crudest form of interactivity simply by reading chapters or sections at random, and using help facilities such as the index and glossary. With interactive systems, it is important to understand how people learn, and to test every programme through and through, to apply conventional production skills to a radically new environment. Fortunately for the multimedia production team, a great body of information already exists to explain these principles and apply them to real models: in the IV trade, all this activity tends to be grouped under the discipline of instructional design (which is discussed in Chapter 5, Designing for Interactivity).

DOCUMENTATION

A multimedia project may begin with the first glint of an idea, and proceed (particularly in corporate markets) through the intricate courtship of client and supplier, with many contract documents and design briefs. How any one project is documented of course varies between companies, as does the choice of terms to describe each stage. However, when the concrete work of production is ready to begin, the team should typically have a document to represent:

- A brief, which supplies an outline of the project, and as much as is known or assumed about its aims, objectives, content, audience, shelf-life, market, budget and schedule. In commissioned work, this is typically prepared by the client to brief potential suppliers, but most in-house projects also begin with a document on this scale simply to evaluate the viability of the project, and allocate resources. As an official document, this may be called an invitation to tender, a solicitation, a request for proposals (RFP) or for quotes (RFQ).
- The proposal, whether submitted from potential suppliers or prepared internally, which suggests a treatment for the programme (describing both structure and

contents in general terms), and estimates the human and material resources which this would involve. In a brief courtship, this may be the preliminary design document on which the detailed design is based. Where there is competition, the proposal has to be persuasive without giving too much away, should the client share some of its ideas with another supplier.

- Both preliminary and detailed design, which typically describe the instructional strategy or philosophy of the programme, as well as its structure and contents. The preliminary design is essentially an overview, or 'ideas map', from which the detailed design is developed to provide the specific content of each screen or segment, and the relationship between discrete units within the interactive structure. The preliminary design may form part of the contract documentation on which the detailed design is developed.
- Flowcharts and diagrams, within or related to the design documents, which illustrate the structure of the programme (initially, with an overview on a single page), and the relationships between every segment in the interactive process. Multimedia flowcharts typically employ the conventions of computer flowcharts (which, for example, define specific shapes to indicate the type or function of each item in the chart), with some form of acronymic code to identify elements unique to audio-visual platforms. In CD-I, the encoding values for audio and video quality levels – Level A or CLUT 7, for example – provide one obvious key to defining flowcharts accurately.
- Style sheets and/or standard practice instructions, which establish the criteria for visual and stylistic conventions. Where such a model does not already exist, the design itself must set guidelines for conventions such as typography and colour-coding, so that everyone in the team is working to common standards. (The issues typically addressed here are described more fully in Chapter 10, Screen Design.)
- The script, which typically provides text for narrators, dialogue for actors, and copy for sub-titles, captions and text screens – in short, everything that is spoken or written in the entire programme. This may represent the work of one or more writers, if a combination of creative and technical skills is required. Where an AV script usually has two columns, to specify words and describe the pictures which accompany them, the script of an interactive programme also notes where 'decision points' occur, and where each one leads, so that the reader can follow through script through all potential paths.
- The storyboard, which provides at least a preliminary sketch of the programme in words and pictures (again, with a complementary key to the interactive options).

The cartoon-strip format of the storyboard may provide a detailed design document on which individual text and graphics screens, and AV segments, are closely based.

The development of flowcharting tools, software for project management, and packages such as Apple's HyperCard means that some or all of this work can be created directly on a computer which simulates the actual appearance and flow of the finished programme. This greatly facilitates the execution of both the audio-visual material and the programming, by providing a model which has already been seen to work interactively, and within the visual constraints of screen design.

The design documents particularly should specify, as literally as possible:

- Visual conventions including specifications for screen layout, grids or matrices, colour schemes, fonts, and graphical user interfaces such as icons and objects.
- Examples of interaction, including the means, tools and options which users can employ at every decision point, and the consequences of each choice.
- The principal assets which the programme will require – the number and content of text and graphics screens, and moving sequences – and their sources, whether they are to be created from scratch or adapted from other formats or media.
- Support material such as manuals or workbooks, as well as packaging and promotional material, which must be prepared or commissioned.
- Guidelines from which writers, designers and programmers can execute their respective contributions to the programme.
- Design issues and constraints which must be respected by designers, or resolved by programmers. (This may include considerations of cost, time, hardware and software, and technical standards for acceptable quality levels, as well as conceptual or political issues.)
- Issues such as confidentiality and copyright, which every member of the team should respect, and targets such as sign-off points for each phase.

The detailed design documents are the blueprints on which the entire project is based. They will probably be amended as the execution of the project reveals problems or inconsistencies which can only be addressed by changes to the structure or content. Rigorous project management is essential to ensure that every change is noted, its consequences anticipated, and every member of the team fully apprised of changes which may affect the content or structure of their contribution.

Naturally, there should also be a set of documents which specify not only sign-off dates, confidentiality and copyright or licensing agreements, but also a schedule for

payments which ensures a steady cashflow to meet salaries, fees and material costs. It is also advisable to agree at the outset the criteria which determine whether the job has been completed satisfactorily, and terms for terminating, re-negotiating or renewing the contract if necessary – and assigning intellectual and material rights in each event. Every schedule and budget must also include a contingency plan, for all projects encounter the unexpected, and new platforms are by definition unpredictable, even where the developer has experience.

OBSERVATIONS FROM THE FIELD

Electronic publishing is an established discipline with some useful lessons for CD-I developers.

For example, speaking at Microsoft's Fifth International CD-ROM Conference in 1990, Greg Smith of Meridian Data estimated that half the time spent developing a CD-ROM database is typically devoted to 'tagging [i.e. converting] data', and the balance to indexing and simulations.

Stan Williams, an old IV hand, cites seven key tasks in any project:[4]

- Evaluate the situation
- Establish standards
- Create plans
- Supply resources
- Provide training
- Monitor performance
- Facilitate feedback (from everyone – clients, suppliers, staff and users)

Williams observes that clerical support is essential to handle day-to-day administration and text processing. He also recommends that a computer network, with identical or at least compatible software on every terminal, be carefully managed to ensure that everyone has access to current information, and that two versions of the same data are not being modified separately in different locations.

Laura Buddine of TigerMedia says, 'The most expensive part is content, the most difficult part is design'.[5] She advises developers to save all drafts, record all experiments, keep a diary, and expect at least a few false starts. She also endorses the use of templates and routines, to effect economies of scale. 'Ask yourself, "What can this platform do?" Design to its strengths, and around its limitations.'

The importance of preparation, and the consequences of decisions, are illustrated in the experience of Interlight Productions, one of the first companies to produce a CD-I consumer title, in *Noah's Ark*, the first in the projected series of *Children's Bible Stories*. The disc, not untypically, took over two years to complete, in the days before any one had CD-I experience or software tools.

To compensate for the lack of video, the team initially decided to use lots of animation, assuming that the right software package could be chosen later. When the time came, nothing met their requirements, and they were led by stages to establish a whole cell animation studio, with a staff of 12, and all which that implies for budgets and schedules. President Jerry Lundquist said 'Most of the company's resources were being devoted to what would constitute more than one-seventh of the disc real estate, and only about one-seventh of the activities on the disc'.[6]

Appraising the finished product, he says, 'we put much more into the disc than we needed to make it marketable – but we found that there is very little if anything, that we'd take out'. The disproportionate volume of work in that first project was vindicated by the decision to develop software as reusable tools which could be employed not only on other discs in the same series, but also in commissions for other clients. In the third year of the venture, Interlight were well satisfied that they could produce bespoke projects well and profitably. This is a reasonable strategy for developers in this new market, but it requires a sound business plan to fund a company on the learning curve.

Interlight also discovered another consequence of long-range planning: a fundamental decision to present the Bible stories without 'proselytizing, doctrine or creative licence' and with due regard for the natural sciences would oblige them to call their next disc *Jonah and the Big Fish*.

Notes

1 Philip Mittelman, CD-I Systems, speaking at the First Multimedia Conference on Interactive CD, London, 18–19 June 1990; sponsored by Philips, Sony, PolyGram and Matsushita.

2 John Gray, Capitol Disc Interactive, speaking at Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.

3 Linda Delaney, Capitol Disc Interactive, speaking at the Society for Applied Learning, 21–23 August 1991.

4 Stan Williams, Seven Steps for Avoiding the Crypt, *Multimedia and Videodisc Monitor*, October 1991.

5 Laura Buddine, TigerMedia, speaking at CD-ROM Europe, London, 21–23 May 1991.

6 Jerry Lundquist, Interlight Productions, speaking at the Second Multimedia Conference on Interactive CD, London, 18-19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.

9

Stages in production

The typical stages in the development of all interactive multimedia programmes follow a similar pattern from computer-based training through interactive video to compact disc. However, for those familiar with earlier models, the fully digital environment of CD-I poses some new challenges. This chapter describes the typical stages in the production of interactive video, CD-I, and the conversion of IV programmes to CD-I formats.

STAGES IN PRODUCTION: INTERACTIVE VIDEO

Interactive video provides a model which may be familiar to many interactive designers, and easily grasped by those unfamiliar with multimedia production. However, there are some important differences between IV and CD-I which influence their two authoring environments, and the conversion of material from IV to CD-I. One producer with experience of several platforms insists that 'CD-I is not the same as videodisc at all, and you must recognize the pros and cons'.[1]

- A typical IV programme is divided between a 30cm/12 inch LaserDisc (which delivers analogue video, and analogue or digital audio) and one or more floppy disks which usually contain the computer program, computer-generated text and graphics, and perhaps student records or other management facilities.
- By contrast, a CD-I programme is entirely digital, and holds video, graphics, audio, text and computer programs on a single-sided 12cm/4.75 inch disc.

This presents both opportunities and constraints to the interactive multimedia designer, in terms which are explained more fully below.

The discussion in Chapter 5, Designing for Interactivity, explains the initial stages common to the design of any interactive programme. Briefly, this work determines the structure and content of the programme, and provides the documents on which all subsequent work is based. These typically include:

- A detailed design document which describes the programme in prose.
- Storyboards which simulate the appearance and flow of the programme in pictures with text.
- Flowcharts which provide a structural overview and detailed analysis of all the interactive options and paths.
- A script, which provides dialogue, text and descriptions of audio and visual material.

These various documents describe the presentation from the different perspectives of the instructional designer, the audio-visual specialist, the scriptwriter and the computer programmer – all of whom, essentially, are authors of the interactive programme.

Software packages such as HyperCard allow designers or authors to create effective prototypes of interactive audio-visual presentations entirely on the computer screen. Prototyping allows the team to test the fundamental structure and content of the presentation – often using the very words and pictures that will appear in the final version – and provides a concrete model on which to base and test subsequent work.

Before the emergence of this range of presentation and authoring tools – which allow users to create interactive audio-visual packages directly on the screen, without programming – prototypes could only be effected, with some difficulty, after the audio-visual production and computer programming were well underway. Now, with such tools, prototyping allows everyone in the team to see how the programme works, what its various elements must accomplish (individually and in relation to one another), and where changes or improvements can be effected before the more expensive and immutable stages of work begin. A prototype can also be a useful tool in explaining the programme to partners or investors who cannot easily visualize the interactive multimedia presentation from the design documents alone.

Once the structure and content of the programme are agreed, IV production typically breaks into several complementary areas of activity (Fig. 9.1).

- Audio-visual production follows conventional lines – shooting original video and photographs, recording original audio (music, sound effects and voice-overs), researching and obtaining library and archival material. Post-production refines all this to assemble the package in the prescribed order on a master videotape.

- Computer-generated text and graphics which will be stored and processed as digital data, independently of the analogue videodisc, are often executed separately by graphic designers who have both the conceptual and technical skills to create visual material on the computer screen. Other computer graphics, text and special effects may be created within a video production facility and recorded on the videodisc alongside the photographic material.
- The computer program which controls the interactive presentation is usually created by another team of specialists, who may use both computer programming skills and proprietary authoring products to create the software which runs the IV package. This package often includes administrative or management software in professional applications such as training or marketing.

As all AV material will ultimately be presented on a medium of high visual quality, IV developers should produce or obtain source material on professional formats of the highest practicable quality, and transfer this as directly as possible (that is, without degrading generations from one analogue copy to another) onto a high-quality broadcast or professional videotape format.

When the package is delivered, the text, graphics and programs on the floppies are often transferred to the hard disk of the user's own delivery system, both for convenience and to protect the floppy disks from wear and tear; however, even this can be challenging for users, so IV designers often try to keep the floppies to a manageable two or three per package. This, in turn, limits the amount of text and graphic images which any one application can easily provide; thus, graphics are often stored on the videodisc as analogue video images, rather than on floppy disks in digital form.

All this work is, of course, highly interdependent, and most IV productions test and simulate as much as possible (sometimes, using videotape to supply raw material which will eventually be produced on videodisc).

- Final testing and evaluation often employs a one-off check disc – that is, a single videodisc cut in real time at a special facility, rather than stamped out on a production line at a pressing plant. This check disc provides developers with the penultimate version of the AV material, to simulate the complete programme. This is often the stage at which typical users test the disc from the perspective of its target audience.
- After this level of testing, additional post-production may be required to prepare the final master tape of the audio-visual material, which is then presented to a professional production facility for processing – mastering and replication – into videodiscs.

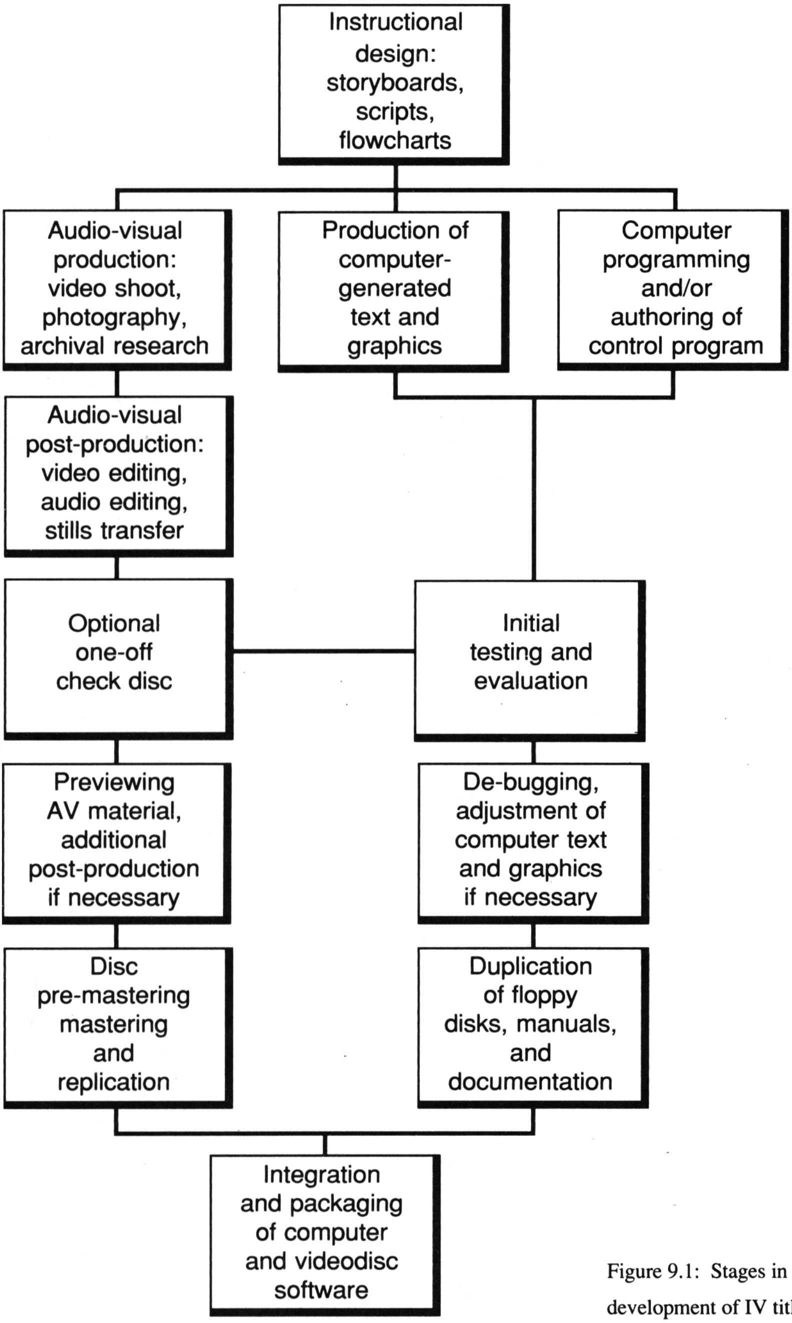


Figure 9.1: Stages in the development of IV titles

- After a similar debugging and refinement, the computer software (text, graphics and control programs) is integrated and duplicated onto one or more floppy disks.
- The process of field testing and evaluation may go on for some time, and result in a second edition of all the software. Much software for professional markets is now produced for a standard range of hardware, but where the delivery system is purpose-built, that configuration of hardware, too, must be tested and evaluated during the development process.

In all types of multimedia development, it is essential to remember that software production only represents part of the project. Other activities typically include the preparation of manuals or operating instructions, the design and production of packaging, the design and production of housing for the delivery system where necessary (as in most marketing applications, for example), and indeed the marketing and distribution of the finished product.

STAGES IN PRODUCTION: CD-I

Structurally, the development of CD-I programmes follows a similar path to the model provided by interactive video (see Fig. 9.2). Technically, several quite different skills are involved and, functionally, the important question of testing and evaluating the material under development is much different in the CD-I authoring environment.

During the development of a CD-I title, all the production assets (that is, the actual material components of the programme) are held in digital form, often after conversion from analogue sources such as video or audio tape or photographic media. Audio, video, graphics, text and so forth, are typically stored on one or more large hard disks in the formats that will eventually be recorded on the CD-I disc. Back-up is often provided on magnetic tape or other mass-storage media.

During production, all the information in the application (including program code and sector data as well as audio-visual material) is brought together for processing to create a presentation which closely resembles the appearance and performance of the finished CD-I disc. The data are first processed to build an image of the data on the disc, and then passed through a special piece of equipment called an emulator, to a real CD-I player. The player receives these data as if they were coming directly from a CD-I disc, with only slight differences in access time, and performs accordingly.

The cycle of disc image building and emulation can be iterative and may be carried out as often as needed during the development of the application. New audio-visual

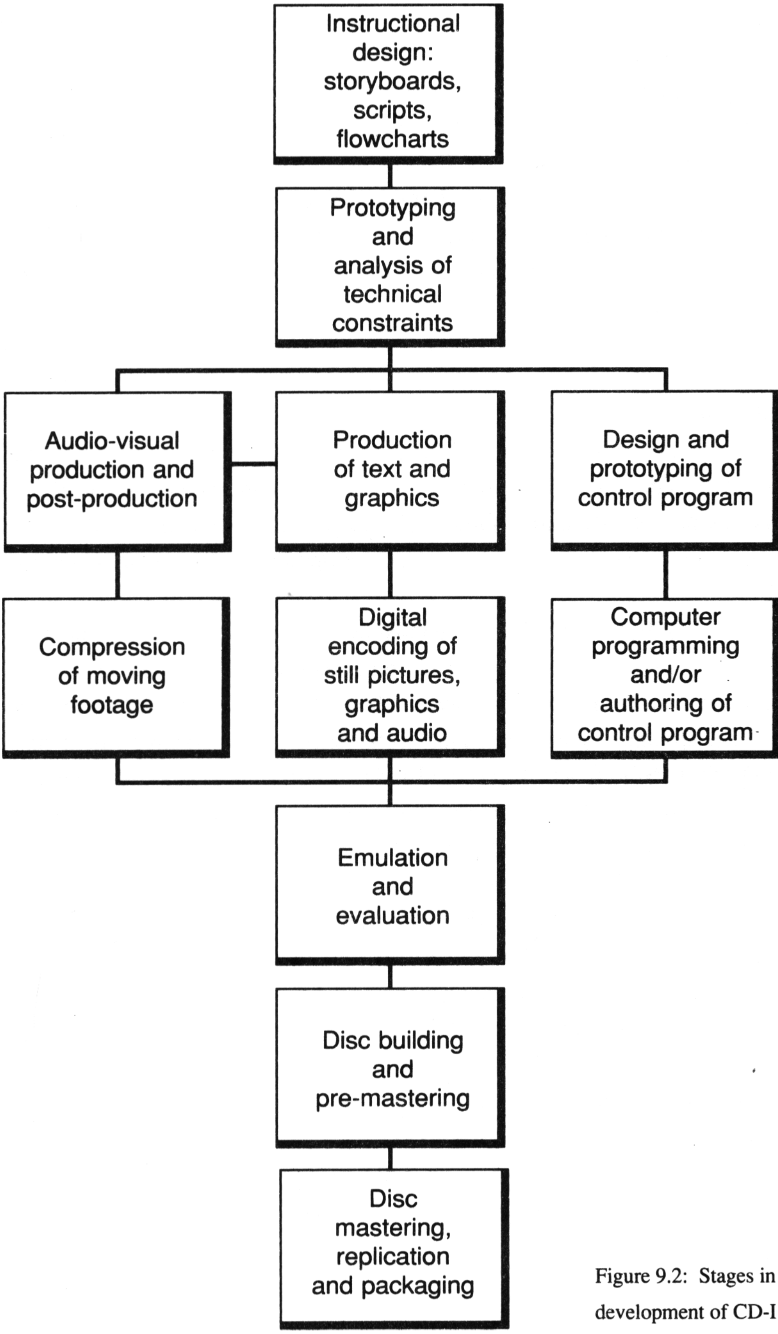


Figure 9.2: Stages in the development of CD-I titles

assets can be produced and included at any time, although in practice it is best to regard this as a contingency, and to restrict spontaneous creativity.

Check discs may be produced, particularly where the client or publisher needs to view or test material at distant sites, or the application is sufficiently complex to warrant an extra level of testing. The final CD-I disc is only produced once the application has been thoroughly tested and amended in this fashion.

From a technical point of view, the mastering and pressing of the compact disc ought to be a routine event, merely committing to plastic an application which has already been thoroughly tested.

Constraints analysis

The essential elements of instructional design are the same whether the end product be a classroom lecture or a CD-I package for the consumer market – research, analysis, and the creation of a structural framework and guidelines for content. The stages and documents described above apply to the development of all interactive multimedia titles.

In both IV and CD-I, this phase demands close attention to the management of assets or real estate, to ensure that the storage and processing capacities of the system are equal to the volume and variety of data required to satisfy the programme's creative and intellectual demands. This seemed like a challenge with interactive video; however, by comparison to the wealth of potential and trade-offs in a CD-I system, getting an IV programme on to one LaserDisc and a couple of floppies was relatively straightforward. This is one area in which prototyping provides a valuable perspective on the relative value of individual elements within the programme as a whole.

In the development of CD-I titles, constraints analysis is essentially a stage in the production process, which informs every decision on the final structure and content of the programme. As CD-I is ultimately a digital computing environment, the equations are straightforward enough: some of the basic calculations are provided in Chapter 7, Audio and Video on CD-I (105KB for a DYUV graphic at normal resolution, 42.5KB per second of Level B stereo, and so forth). What is daunting is the sheer number of equations, and subsequent permutations as trade-offs are introduced. Fortunately, this sort of number-crunching can be consigned to a computer, but the creative decisions at the heart of the equation necessarily remain with the designer.

Converting audio and video

Every producer needs a certain amount of dedicated hardware to create CD-I software, and some developers have installed full suites of equipment: the CD-I Studio is discussed more fully in Chapter 11, Programming. There are invariably some jobs which are most cost-effectively commissioned from an external supplier with the equipment and resources to do a large or specialized job. However, the emergence of new productivity tools (in the form of hardware and software) means that developers can accomplish many activities in-house without a disproportionate expenditure on equipment, recruitment and training.

The next sections discuss the conversion of audio and video material from other environments and media into CD-I formats. This is one field where proprietary authoring products can relieve the production team of many tedious technical jobs, and ensure some level of consistency in the production process.

Converting data from one file format to another is a common feature of most modern computing environments. Many users regularly exchange disks between, say, an IBM PC-compatible computer and an Apple Macintosh. The two platforms are fundamentally incompatible, but both employ technical principles common to all computers. Thus, a report written on an IBM or compatible desktop computer can be stripped of the formatting which prepared it for the PC screen, transferred to a Mac as a simple text file, and re-formatted there for display in a different environment.

Products such as the Image and Audio Conversion package developed by Philips and OptImage provide a similar service for CD-I developers. The package is available for PC-compatible and Apple Macintosh computers, and Sun workstations – the platforms which CD-I developers now principally use. It comprises:

- Image Conversion Utilities (ICU) which accept computer graphics in a variety of familiar file formats (RGB 8:8:8, PICT 8, PICT 32, Targa or Vista) for conversion into CD-I's DYUV, CLUT 8, CLUT 7, CLUT 4, RLE 7 and RLE 3 formats.
- An optional CD-I Plug-In for Adobe PhotoShop, a popular product in the Macintosh environment for the editing and manipulation of digitized photographic images. With the Plug-In, photographic images including transparencies and slides can be captured and edited with PhotoShop's specialized facilities, and converted directly into CD-I files of various kinds.
- Audio Conversion Utilities (ACU) which accept digitally-encoded PCM audio data in the industry-standard Audio Interchange File Format (AIFF) for conversion to CD-I's Level A, B and C in stereo or mono. (Digidesign supply hardware and software to capture and edit audio from various sources as AIFF PCM files.)

Clearly, an array of hardware and software is required here, both to capture and edit audio and visual material. Chapter 11, Programming, considers these requirements in more detail; in this chapter, it is important to remember that tools already exist to facilitate many of the tasks described here, and that more products are likely to enter the market in the next months and years.

Audio processing

The audio elements of a CD-I package may originate in analogue or digital sources.

- Analogue audio usually comes from quarter-inch tape, ideally with SMPTE time codes (the international standard set by the American Society of Motion Picture and Television Engineers). Digital audio is usually supplied on digital audio tape (DAT).
- The analogue signal must first be digitized at the correct sampling rate (37.8kHz for Levels A and B, 18.9kHz for Level C) using appropriate analogue filters.
- This audio must be transferred in real time to a high-speed hard disk with appropriate (usually, large) storage capacity.
- Digital audio which is supplied at the CD-DA sampling rate of 44.1kHz must be 'sample rate converted' to Levels A, B or C, using special software. With source material of this quality, it may be easiest to convert the digital audio to a more manageable analogue format simply by re-recording it from a digital audio tape or CD-DA disc. There will be little discernible loss in quality, and the analogue recording can then be re-digitized at the correct sampling rate for CD-I using the correct filters, in the stages described above.

However the audio is captured and processed, the data will be stored using Pulse Code Modulation (PCM). This is the encoding system (developed in 1938 after nearly a century of theory and experimentation) to convert digital sample values to binary code as a series of pulses. In PCM, a pulse represents 1, no pulse represents 0, so a long string of binary code can be transmitted very quickly, and recorded and re-recorded without significant loss of quality.

- Once converted to the PCM form, audio can be edited in a variety of ways as digital data. This typically ranges from simple cutting and pasting, which can be effected on a desktop computer, to sophisticated mixing, blending and filtering which require a fairly high level of workstations, software and technical skills.
- The edited PCM audio is then encoded (not in real time) to ADPCM, the audio encoding method developed for CD-I by Sony.

- Finally, the ADPCM audio, at the appropriate levels for CD-I, is stored on disk in the AIFF file format which is the international *de facto* standard for audio data. Audio in this file format is built into the disc image when all the material is ultimately brought together during the next phase of development.

A studio which specializes in music programmes, or even composes music, may invest heavily in the customized hardware and software to create, edit and encode digital audio; in the early nineties, Apple Macintosh computers and Digidesign audio products are popular. But most producers turn to a professional sound studio to produce the master audio material, and let another organization bear the cost of maintaining and upgrading equipment (and operators) for this special craft.

Image processing

The various encoding systems available to the CD-I designer require different activities during the production phase. Both DYUV and CLUT images may originate as 35mm or large-format photographic transparencies, flat art, graphics from a sophisticated paint package, or still frames grabbed from video or converted from film. Transparencies, particularly 6x7cm or larger, provide the best source material for a suitably-adapted RGB scanner or camera with at least 600 line resolution for each level of red, green and blue.

Any of a number of proprietary frame grabbers or colour scanners can be used to digitize analogue video stills directly from videotape, transparencies and flat art. A camera can be quicker than a frame grabber or scanner (given that most time is devoted to adjusting orientation and scale, rather than simply snapping the image), but cameras usually require more skill and attention from a trained operator than scanners. Some 35mm slide scanners can also be used, but tend to be slow.

It is essential to ensure that the heart of the captured image lies within the screen's safe area (either by checking this before capture, or adjusting the captured image afterward). It is also important to establish firm guidelines (or use expensive tools such as X-Y positioning tables) for technical tasks such as masking and positioning the images for capture, both to improve productivity and ensure consistency.

Adjustments to any one image will be affected by the quality of the source material, ambient lighting in the studio, the quality and adjustment of the scanner and its monitor, and the personal taste and professional experience of each operator. Subjective judgements are inevitable, so it is important to set guidelines and monitor all captured images for quality and consistency, with particular attention to undesirable 'artifacts'

and extreme levels of contrast which may disfigure the image at CD-I's relatively low resolution.

Material developed on the dedicated hardware of the production studio can look quite different on the end-user's screen, so it is essential to 'preview' captured images as early and often as possible. Since CD-I still offers lower resolution than television, it is important to view all video material on NTSC, PAL and SECAM monitors (typically, on an industrial-quality composite monitor which handles all three standards as well as RGB signals). As well as the general aesthetic effect, it is important to ensure that all vital data are within the screen's safe area, that text is legible, and saturated colours and other potential trouble-makers are under control.

- Captured images, whatever their source, usually need some editing to be displayed to best advantage on a CD-I screen. Typically, this may involve changing or adjusting colours; defining or anti-aliasing lines or outlines (explained below); cropping, rotating or stretching images and objects to suit the size and shape of the display; or adding texture to flat objects or backgrounds.
- DYUV images specifically should be digitized at high resolution (using a full eight bits for each RGB component if possible), and filtered and re-sized as necessary to normal resolution to remove undesirable artifacts.
- As digital data, these images can then be edited within a paint package (typically, on a computer with 16- or 24-bit colour resolution) before processing into CD-I format. Re-sizing may be necessary to adjust the new image to the CD-I screen, and filtering may also reduce artifacts.
- After editing, re-sizing and filtering, the digitized image can be encoded to the DYUV format (which is most appropriate for photographic images with soft edges and subtle colours) or CLUT (for graphics with sharper colours and definition).
- CLUT is also the most appropriate format for images which are likely to be manipulated in run-time within the delivery system (for example, to display text in the same image plane, or create animation).
- Run-Length Encoding is effectively a variation on CLUT which adds an extra level of compression and decompression to support simple animation at run-time. RLE animation can start with line art or computer graphics but must be colour-coded on the computer, so the digital data are in the right format for compression.
- RGB 5:5:5, at the other end of the scale, demands high data storage and processing, and offers few economies by comparison to conventional RGB graphics, and so tends to be used only for images such as small or complex text fonts, which demand high-quality reproduction.

Of course, in any medium, the quality of the reproduction depends on the quality of the original image. Every time material is transferred from one format or medium to another, the image quality slips by one generation. In purely digital environments, multiple copies can be made with no loss of quality, but there is often significant degeneration as material is transferred from, say, flat artwork to analogue video to a digital graphics format. In multimedia applications of all kinds, it is important to reduce the number of successive generations to the absolute minimum, and use pristine source material wherever possible.

It is sometimes easier to re-create images from scratch, as new computer graphics, than to struggle with poor source material. Where the model exists in another medium, relatively little creative effort is required to execute a computer graphic along the same lines – for it is the creative, rather than the functional, part of graphic design which can be the most time-consuming in any medium.

Even where the source material is good, it is often easier to create a computer graphic within the technical constraints of the CD-I platform, than adapt a digitized picture from a radically different medium. The paint facilities within the CD-I system itself are still limited by comparison to the best products on the larger market, but CLUT images are similar to 8-bit computer graphics created in the Macintosh or PC environments, where there are many excellent proprietary paint packages. Products such as the Image Conversion Utilities, described above, convert standard computer graphics file formats to CD-I encoding in the various DYUV, CLUT and RLE formats. (There may be small differences of vocabulary: the palette of a paint package is equivalent to a colour look-up table, and palette switching effectively means CLUT cycling.)

Paint software for a IBM-compatible PC or Apple Macintosh can create graphics with similar resolution, colour spreads and aspect ratios to those of CD-I CLUT images. New Media's Technical Director, Graham Sharpless, notes that 'Mac and PC displays use CLUT format, so there should be no surprises'.

Data converted from other formats often acquire a sort of electronic debris which distorts the sampled image or audio track. Typical causes for this may be an insufficiency of samples to reconstitute the data in digital form, or (in audio) signals which exceeded the pre-determined limits of the sample; whatever the cause, the result is often artificially-calculated values, or aliases, which were generated to meet the deficiency but which do not fit comfortably, and cause visual or aural distortion. Anti-aliasing filters out these rogue signals before sampling, and makes digitized images more acceptable.

- After digitizing, images (including text fonts recorded as graphics) often require filtering or anti-aliasing, to remove undesirable artifacts, smooth rough edges on sharp lines and stepped curves, and graduate the spread of colours (for example, across a photographic image or textured background).
- Digitizing often distorts thin lines, particularly in irregular shapes, so that a line which ought to maintain a constant width may vary or even break; manual re-touching, anti-aliasing or lowering the contrast within the image can reduce the visual impact of this phenomenon.
- Filtering and anti-aliasing can effect significant improvements, but they can also make some images look fuzzy and reduce the impact of crisp lines and shapes, so attention is required in the design of original graphics, the choice of encoding method, and the effects of filtering, to reduce unnecessary distortion.
- Smoothing can also increase the number of discrete colours in any one graphic to the limits of the look-up table or encoding technique. (New Media found that a single map, which used only 8 colours as flat artwork, was initially encoded with 32 CLUT locations, and finally employed 48 different hues by the time it was smoothed to create a pleasing image on the screen. This is how photographic images, on a much larger scale, easily employ DYUV's extensive colour spread.)

Where last-minute adjustments are necessary, it is usually preferable to do this through the player or CD-I compatible hardware rather than attempt to re-work and encode the image at source, particularly where the same problems arise on several graphics, and can be addressed globally in a single automated editing process.

Motion video processing

At time of writing, CD-I does not support full-motion, full-screen video except in demonstrations. In the meantime, partial-screen updates and video windows (described in Chapter 7, Audio and Video on CD-I) provide an interim solution which can be quite stylish, and often better suited to the real demands of the programme than conventional video treatments.

- Moving images from analogue sources such as videotape are captured and digitized in much the same way as the video stills described above, as video and film comprise no more than a long series of still frames, which can be digitized and processed like any other computer graphics. Re-sizing and editing facilities may be required to tailor the material to the lower resolution of the CD-I screen.

- Once the images are ready for processing, they are (at time of writing at least) typically converted first to DYUV (the best format for photographic images) and thence encoded again to the UVLO format which supports part-screen motion. This requires complex facilities, so far provided as a service only by large developers such as Philips and PIMA.
- All visual material is ultimately encoded in IFF file formats which can be built into the final disc image, and emulated.

In one interesting experiment, CD-I Systems used a motorized camera, which captured images at a rate of six per second, for some of the animated sequences in *Caesar's World of Gambling*. Photographs produce stills with higher resolution than videotape, but one particularly fast sequence (dealing cards) had to be re-shot on video, and the producers elected to use video in future, and trade higher resolution for greater versatility.[2] Equally, the designers of the *Dr. Wellman* CDTV disc – which employed low resolution images and medium resolution text – observed that TV audiences expect a higher quality of images on the screen.[3]

For more information on the quest for full-motion, full-screen video from a compact disc, see Chapter 2, Multimedia Platforms.

Program-related data

'Program-related data' is the phrase used in the *Green Book* specification to describe all data which are not specifically audio, video or program code – that is, run-time text, indexes, hotspot and navigation data and other bits and pieces which make up the complete presentation.

- Text, particularly, may need to be previewed, edited and re-formatted for display on the CD-I screen. Large blocks of text may be pre-formatted during the development phase, or formatted at run-time as the presentation unfolds.
- Hotspots can be created with paint software, using the X-Y co-ordinates on the screen (or, ideally, the grid or matrix which is the universal model for all screen design within the project).
- Navigation aids such as indexes, as well as discrete databases, are best created with a proprietary database management system (DBMS).

These are the routine tasks typically addressed by an authoring product such as those discussed in Chapter 11, Programming.

Program development

Programming in the CD-I environment falls into three main areas of activity:

- Previewing encoded audio-visual material, and building real-time files (typically, by laying down the audio sectors, which must follow a strict sequence, and then arranging other data, including padding, in the remaining sectors).
- Writing control software to define the sequence in which data appear, and the decision points or links (hotspots) which initiate branching and interactivity.
- Building disc images by creating the disc label (which includes header data, and the structure of paths, directories and files), laying down real-time and non-real-time files, adding sector headers and sub-headers and, finally, scrambling the data.

In practice, this usually represents a long cycle of previewing, programming and testing, usually working with one small disc image (i.e. segment of the application) at a time. This issue is discussed in more detail in Chapter 11, Programming, but the key points are iterated here.

- In the absence of good authoring tools and products, program development has tended to be carried out in the general-purpose computer language C, using the CD-RTOS libraries and C bindings from Microware. (To do this, a C compiler, preferably with optimizer, linker and debuggers is essential.) Much CD-I programming is object-oriented, so languages like C++ may prove attractive if a suitable C++ compiler becomes available.
- Programs can be compiled on a CD-I player or cross-compiled on a host system, but the code tends to be debugged on a CD-I player. (This is one tedious activity which new software tools should automate dramatically.)
- The minimum function library for this activity comprises the CD-RTOS C bindings to allow access to the CD-RTOS function calls. Additional function libraries are now becoming available, to handle commonly used facilities such as display screen handling, visual effects, pointer and cursor control, playing real-time files and meeting users' requests and switches.

The development of software products for CD-I developers is also seeing the emergence of programming tools such as run-time engines (to recycle a versatile piece of code as often as it's needed) and code generators (to obviate the need for every programmer to write common routines from scratch).

In the interim, many designers are using versatile information products such as HyperCard to test and simulate both the content and structure of the interactive

presentation before committing long hours to the development of computer code. Other aspects of the programmer's creative activities include:

- The design and prototyping of interface tools and routines for users, which may include the design of menus, hotspots and cursors as well as conventions for the use of graphics and responses to users' requests.
- The creation of timelines to control picture essays and other real-time sequences which users may manipulate during the interactive presentation.

Problem-solving at all levels is still a large part of the CD-I programmer's job. The newest authoring tools in CBT and IV environments require relatively few programming skills, but CD-I programmers still require a high order of ingenuity and expertise, as well as training and experience, to produce successful titles and build up a new repertoire of tools and techniques.

Image building and emulation

CD-I data are typically created and processed on a variety of purpose-built professional systems, but ultimately consigned to a single compact disc. To evaluate the programme before (or without) actually pressing a check disc, the CD-I authoring process employs an emulator to preview work in progress.

The emulator is a subsystem with an industry-standard SCSI bus which stands in a single cabinet, between a Macintosh or IBM PC-compatible computer or Sun workstation, and an ordinary CD-I player. The emulator passes data collected on the computer's hard disk to the player as though the signals were coming directly from a CD-I disc. Thus, the authors can emulate the appearance and performance of work under development, and make necessary adjustments. The emulator effectively formats or pre-masters all the data in the application, typically by building real-time records and files and, from these data, the disc image itself. The emulator can also generate the pre-mastered magnetic tape from which the master tape and, thus, the compact disc itself are produced.

- During disc image building, all the data intended for the CD-I disc are created as one large computer file – with audio, video and computer codes simulating every aspect of the disc down to the header code of each sector. This takes time, so the build software should run as quickly as possible – and should allow developers to edit individual items without having to re-build the disc image after every amendment.

- This build software should support real-time files, and allow real-time sequences to be packed in parallel where this simulates the performance required of the CD-I disc.
- Real-time files must be built first so that audio sectors can be allocated. (The real-time builder typically uses a source such as a script to create a map of the sector allocation.) This should allow real-time sequences to be interleaved, and should use the timeline which was validated during programming.
- Debugging is important at this stage, particularly in these early days when so much hardware and software is only in the first or second generation of its own development. It is also important, when there is little experience to provide rules of thumb, to ensure that the hardware on which the programme is being validated is itself performing according to the *Green Book's* specifications.
- The sector map, together with a list of non-real-time files, is used to create the complete file of CD-I sectors which also may be used for disc mastering.

With the growing use of authoring products, which help non-programmers to develop software for CD-I products, at least some of this work may be commissioned from an external supplier. Productivity tools such as the CD-I Starter Kit, or MediaMogul authoring package (described in Chapter 11, Programming), allow developers to concentrate on the creative aspects of the production, and consign some of the technical jobs to Philips and other specialists for processing.

All this – to emulate a disc which itself can hold 650MB of compressed data – may easily require the better part of a gigabyte's worth of storage: with 2352 bytes per sector, 75 sectors per second, 60 seconds per minute, up to 72 minutes per disc, this equates to some 762MB of raw data. This is why CD-I developers tend to employ dedicated workstations and large-volume magnetic storage media such as 9-track or, increasingly, Exabyte tape.

Disc mastering

Within the CD-I development process, data is effectively pre-mastered or formatted during the disc building process. It may be useful, at least once in the production process, to press a WORM (write-once read many) check disc that will emulate exactly the performance of a real CD-I disc. This can be done for a few hundred dollars or pounds at an external facility, or even in-house, if the volume of work justifies the expenditure on hardware.

With frequent or at least periodic emulation, of work in progress or the disc as a whole, the application should be thoroughly tested, amended and debugged by the time

the master tape is eventually produced. This will hold all the data for the disc – audio, video, program-related data and program code – in real-time and non-real-time files, encoded and arranged exactly as they will appear on the CD-I disc itself. This tape is then sent to a professional production facility for mastering, pressing and replication – for the foreseeable future, the last phase of the production process is consigned to an external supplier, in much the same way as publishing in most other media.

CONVERTING IV TO CD-I

Conceptually, IV and CD-I are similar platforms, divided only by the technical barriers of analogue video. All the digital data in an IV package – the control programs, management software, and computer-generated text and graphics – can be transferred to CD-I easily enough. However, until compact disc formats support large quantities of full-motion, full-screen video, some parts of the IV programme may need to be adjusted to the different technical capacities of the CD-I platform.

Equally, CD-I's greater facility with graphics and real-time image manipulation may enhance some of the many IV programmes which now tend to follow a pattern of video/text/video with little creative use of other resources. A new range of digital video graphics and editing systems now offers IV designers more flexibility, but most IV developers still create and record all the visual material for the disc, including special effects, in a professional production facility, in precisely the form in which it appears in the finished programme. CD-I, by contrast, tends to record source material intact, and manipulate both sound and pictures in various ways during the course of the presentation, using the player's own processing facilities. (The discussion in Chapter 7, Audio and Video on CD-I, explains these effects in more detail.)

IV is restricted to the use of two image planes, one provided by the videodisc, the other by the computer. This offers three choices: full-screen video, full-screen computer text and graphics, or video with computer-generated overlays. CD-I can now combine visual material on its two central image planes in many ways, and will eventually use the backdrop plane for full-motion, full-screen video as well.

IV material can be transferred fairly directly to CD-I by displaying all the IV's computer-generated material on CD-I's Plane A (in the foreground), and re-encoded AV material for display on Plane B (in the background). Eventually, moving video will be displayed on the backdrop plane; the cumbersome interim solution would supply moving video from a videodisc player to the backdrop as an external video source.

IV's use of two such different storage media also poses some functional challenges on CD-I's single disc. The CD-I disc has finite data storage and processing capacities which impose certain constraints on the type and volume of data which can be presented at any one time. A demanding medium such as moving video occupies most of the available data channel and processing power of the system, so that other data can only be loaded and processed selectively. The phase of the CD-I production activity which identifies technical constraints will alert the designer to potential problems, which can be addressed with modifications to the audio-visual content of the package.

Data processing

For conversion from IV to CD-I, the typical components of an interactive multimedia programme require specific treatment. As the videodisc is itself some generations removed from the original source material, these conversion processes should, where possible, draw on the master tape from which the disc was produced, or the source material which went into the original IV production.

Philips' Drs. Jean-pierre Isbouts observes that images captured directly from disc display lower resolution than CD-I, as well as unacceptably low contrast and luminance levels. 'If our source image was not of the very highest possible digital quality, there would be little or nothing some enhanced engineering process could do to it.'[4]

- Moving video must be digitized and compressed – ideally, from the original master tape or source tapes, rather than the re-processed material on the videodisc.
- Still video and photographic material must be digitized and encoded to CD-I formats – probably DYUV – again, from the best available source material.
- Graphics which originated as conventional artwork or archival material must be digitally captured and converted to a CD-I format – typically, CLUT – either from the master tape or source material where available.
- Digital graphics can be converted to CD-I formats – usually, CLUT at the appropriate level – from original computer graphics paint files.
- Animation must be converted to CD-I as individual run-length images or recreated as animated sprites with specially-written computer code.
- Run-time text can be converted directly to CD-I formats or re-generated with new fonts within the CD-I environment.
- Control code must be converted into CD-I code or re-written as CD-I code.
- Hotspots must be converted to the appropriate CD-I format for the CD-I user interface program code.

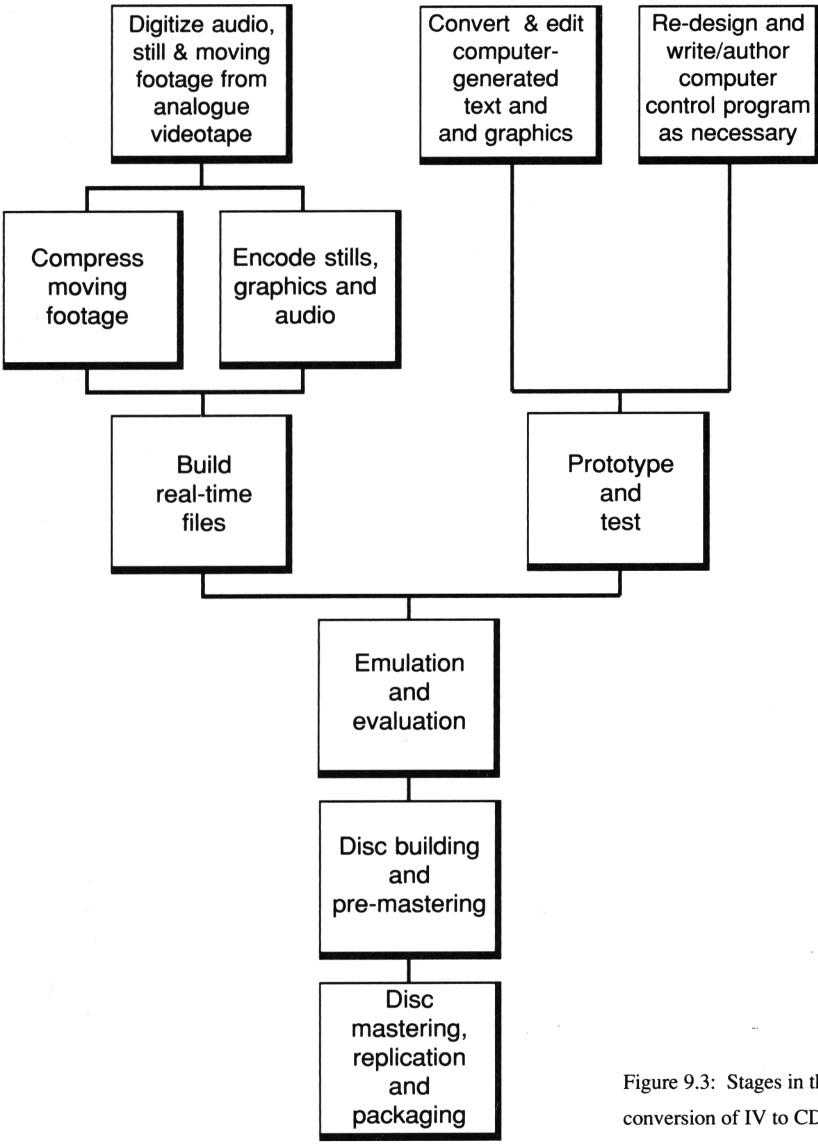


Figure 9.3: Stages in the conversion of IV to CD-I

Theoretically, all this could be accomplished by one spectacular computer program. In practice, the conversion process usually involves some 'blind conversion' from one format to another, plus a good deal of editing and amendment to refine the converted

material, and some work to re-create material which cannot satisfactorily or economically be converted from source. Even where material has to be produced again, the detailed model provided by the IV programme greatly facilitates the creative side of the process, so long as designers are not tempted to introduce changes and refinements which affect the structure and content of other parts of the programme, and transform the routine process of faithful copying into a new creative exercise.

Production stages

Emulation is essential in cross-platform or bridge projects, for the new title should resemble the model as closely as possible, and only introduce changes where these are dictated by technical differences between the platforms, or there is a sound case (creatively and financially) for introducing new material or features. The conversion of titles developed on IV typically comprises the following stages (Fig. 9.3):

- Convert and encode analogue audio and video signals from the IV programme's master videotape to digital CD-I formats.
- Build these data as one or more real-time files which simulate, as nearly as possible, the structure and performance of the IV programme. This should include still and moving images to re-create the original model accurately.
- Test and prototype the programme, using both still and moving images, to check or identify the location of still images and start positions of moving footage.
- Redesign the software as necessary to allow for differences between the IV implementation and the CD-I features to be used.
- Re-write the software in the appropriate language for the CD-I package.
- Build text, graphics and program code with the real-time files and emulate the application.
- Master and press CD-I discs and conduct final testing and evaluation. (With the original IV programme for a model, and frequent emulation during the development of the CD-I version, there should be no need for a check disc.)

This activity also includes the conversion of all data to appropriate CD-I formats.

- Converting moving footage (probably from one-inch analogue videotape to full- or partial-motion as digitized images) is usually accomplished at a professional video facility rather than the CD-I studio. The developer will need to specify the

size and position of the video window on the source material (even if this is full screen) and the size to which the compressed image is to be reduced. This maximum size depends on the both frame rate and the associated audio level, to determine what space is available in the data channel. Typically, four sectors per frame are available at a partial-motion rate of 12.5 frames per second with Level B mono audio; this works out at 9KB per frame (that is, 9296 bytes or 14 873 pixels). The frame width and height must both ultimately be expressed in multiples of four pixels.

- The compressed video and audio from the master tape will be returned on digital tape (Exabyte or 9-track) for building into real-time files. The format will probably be in CD-I sectors, but the essential header data (described in Chapter 6, CD-I Discs and Drives) must be added separately with the build software.
- Still images which were created as computer graphics can be converted directly to CD-I formats, although differences in resolution will require some re-sizing and perhaps re-touching. Stills from the videodisc can be re-photographed with a high-quality RGB camera and capture hardware, and encoded to DYUV as digital data. If visual quality is important, the images can also be re-created with a paintbox, and then converted to CLUT or DYUV.
- Converting the IV computer program to CD-I will always require some re-design to allow for the differences between the platforms and, perhaps, to exploit the different functionality of CD-I. Where the IV title was developed in a different environment, it may be necessary to re-write or author the entire program; however, as with re-designing visual material, this is much less demanding when the working model exists, and at least some tools or library routines may facilitate part of the job.
- Building and emulating the application will require dedicated hardware and software. Moving video and other real-time files are built first, and development will typically proceed by stages, with testing at every stage, until the program is complete with non-real-time data such as application files.

When the whole application is finished, a master digital tape is produced from which the CD-I disc can then be mastered and replicated. The final stages of this, like any other interactive multimedia project, typically also include packaging, field testing, marketing and the many other commercial and administrative tasks of publishing, whether for consumer markets or in-house productions.

BRIDGE DISCS

The conversion of a straightforward CD-ROM title to multimedia is effectively a variation on the CD-I production process. The project which starts with a successful CD-ROM title already has many material assets (all in digital form, of course), as well as some informed view of the product's reception within its target audience or market. However, the greater functionality of CD-I justifies some fundamental changes in the structure and, particularly, the audio-visual content of material developed originally within the confines of CD-ROM. Thus, the project essentially starts from scratch, and adjusts budgets, schedules and resources to incorporate as much of the original disc (and research) as suits the new platform.

The extended architecture of CD-ROM XA is often described as the bridge between CD-ROM and CD-I. The logical extension of this metaphor is the bridge disc, which employs the CD-ROM XA format to create programmes which will run on a suitably-equipped IBM-compatible PC and a CD-I player.

In the world of distance learning and just-in-time training, bridge discs can deliver data on the office workstation or the domestic entertainment centre. As applications software of all kinds begins to employ digital video – in spreadsheets, word processing packages and the like – certainly more business information is likely to be published on CD, and whole new markets may open up for discs which can be interchanged between domestic and professional environments as easily as VHS videotapes are now.

The specifications for CD-I's *Green Book*, and the extensions to CD-ROM's *Yellow Book*, identify the principal distinctions between the two platforms:

- CD-ROM XA typically runs on an IBM or compatible PC with the MS-DOS operating system (and XA board); CD-I has its own dedicated drive or player, with its own CD-RTOS operating system, based on industry-standard OS-9.
- CD-ROM XA typically employs a computer with a mouse and keyboard; CD-I usually employs its own hand-held remote controller with dedicated keys and a joystick.
- CD-ROM XA supports MCGA and VGA computer graphics, and CLUT and RLE image coding; CD-I supports RGB 5:5:5, DYUV, CLUT and RLE.
- CD-ROM XA offers up to 256 colours, compared to CD-I's practicable 32 000, both from an ultimate choice of 16 777 216.
- CD-ROM XA supports resolutions of 320x200 (MCGA), 640x480 (VGA) and 800x600 (VGA+); CD-I has a safe area within the screen of 320x210 (NTSC) or 320x250 (PAL/SECAM) in normal resolution, 640x210 (NTSC) or 640x250

(PAL/SECAM) in high resolution, and 640x420 (NTSC) or 640x500 (PAL/SECAM) in double resolution.

- Both platforms offer CD-DA and, more practically, ADPCM audio at Levels B and C; only CD-I supports Level A audio.

The lack of Level A audio on CD-ROM XA is not critical, for that high quality is rarely required in a multimedia title. The essential differences lie between the operating systems and image displays of the two platforms, as well as the input devices characteristic of their delivery systems: in the workplace, CD-ROM XA systems are likely to have the monitor, computer, keyboard and mouse of professional computing, while the CD-I system at home may use the family TV and the system's own thumbstick controller.

To address this, Next Technology and Philips have developed a bridge library which complements the Balboa libraries already familiar in CD-I programming, to support the C programming language with routines which allow the same basic data to be processed variously for the two platforms. The bridge library is distributed like any other proprietary authoring tool to assist developers and encourage publishers to provide more software to the nascent market.

Versatility of another kind may yet be a feature of the CD-I market. CD-I systems were of course designed to be universally compatible, but as the inevitable competition between manufacturers encourages the development of extra features (such as control devices other than the standard keypad with joystick), developers may have to address several hardware options in one disc. The advice from the interactive video market here is 'avoid device-specific features as much as possible'[5] – at least where different players have incompatible whistles and bells, or similar features work in critically different ways across different platforms.

CD-I developers, for all the hurdles crossed in the first years in a new authoring environment, may face a fresh round of challenges as interactive multimedia formats converge, and a new generation of hybrid products and platforms emerges. Just as qualified IV producers are well-positioned now to make the best use of interactive compact disc formats, so the experienced CD-I developer should be ideally placed to keep abreast of this rapidly changing and competitive market.

New Media's Creative Director, Philip Smith, says 'there will never be only one multimedia platform – the best advice is to keep design clear of all platforms'.

SAFE COPIES

There are obviously many administrative tasks, from financial management to filing, which any production facility must address with both material and human resources. One task which many developers ignore is that of keeping extra copies of all valuable work in some safe place, preferably at a site geographically removed from the production studio. (Another is adequate documentation – with safe copies – both for the components of the programme, and for the progress of the project as a whole.)

Fire-proof safes are expensive and some, designed for valuables in other media, can actually corrupt magnetic computer disks and tapes. The safest alternative is to make back-ups regularly, and store these elsewhere, taking care to label everything clearly, and provide casing which protects all copies from corruption or damage *en route* and in storage. It may be handy to keep back-ups within a short journey of the authoring studio, so work can be retrieved easily in the event of small mishaps during the working day.

Of course it is tedious regularly to make back-ups and transport them between sites. Some attention is also required to ensure that the copies are up-to-date, and that redundant back-ups are not slowly accumulating off-site, wasting reusable resources and laying traps for the unwary. The incentive is simply to imagine what would happen if work were irretrievably lost, and to anticipate the very worst by keeping regularly updated copies in a safe, safe place.

Notes

1 Mark Dillon, GTE Imagitrek, speaking at the Society for Applied Learning, Orlando, 20–22 February 1991.
2 Philip Mittelman, CD-I Systems, speaking at the First Multimedia Conference on Interactive CD, London, 18–19 June 1990; sponsored by Philips, Sony, PolyGram and Matsushita.
3 Jeremy Rihll, Digita Multimedia, speaking at CD-ROM Europe '91, London, 21–23 May 1991.
4 Drs. Jean-pierre Isbouts, The ArtSpace Group, Philips Interactive Media of America (PIMA), speaking at the Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.
5 James Whinfield, Learncom, 'Lessons Learned in Porting Videodisc Courseware', *The Videodisc Monitor*, August/September 1988.

10

Screen design

Versatile and effective screen design in CD-I demands both creative and technical understanding. This chapter considers the conceptual and technical issues which influence the work of the graphic designer. Technical background is provided elsewhere in this book:

- Appendix 1, Video and Computers, introduces the technical aspects of the television screen.
- Chapter 7, Audio and Video on CD-I, provides specific data on CD-I screens (including screen dimensions and safe areas), explains CD-I's four principal encoding methods (DYUV, RGB 5:5:5, CLUT and RLE) and their variations, and discusses how various effects are created in CD-I's digital environment.
- Chapter 9, Stages in Production, and Chapter 11, Programming, address the work of preparing images for the CD-I screen.

Features of screen design are also discussed, indirectly, in Chapter 5, Designing for Interactivity, and the case study in Chapter 12 includes some examples of design issues from a real CD-I project.

INFORMATION VERSUS DECORATION

Good design can go a long way to attracting and keeping the user's interest, no matter what the content of the publication or programme. Sharp layout, snappy captions, interesting pictures and intriguing charts – and the power of motion – can transform a wall of dry text into a presentation which users will approach enthusiastically, and use again and again with rewards every time.

Good screen design is equally a matter of information and decoration. Much information is enhanced by creative presentation, and some positively depends on illustrations to explain concepts which are difficult to describe in words alone. A combination of text, commentary and images can elucidate both facts and ideas.

At the same time, where any number of formats might be used, a lively combination of techniques could be vital in keeping the user engaged during dull or difficult passages. A variety of presentation techniques also helps to satisfy different learning styles, or approaches to new information, which virtually any audience embodies. Most people, too, understand and retain more new facts and ideas, the more their senses are engaged during the learning experience: reading text screens and hearing commentary, for example, reinforces learning more effectively than text or audio alone. To provide a range of facilities for different needs, it may be useful to:

- Provide as many optional features as possible – captions or sub-titles for those who want to see the text, audio prompts for those who enjoy the stimulus of constant reassurance.
- At the same time, allow users to turn optional displays on and off at any point in the programme, and not just in the first moments of each session.
- Provide help facilities which are accessible at any point in the programme. These may be found through an icon which appears on most or all screens, or a simple routine that is easily found or remembered. Help should explain the conventions of each programme for new users or those who have not used the package recently.

Where a single programme may address a number of disparate audiences, it is often useful to design the main body of the presentation for one, primary target audience, and provide a range of options for secondary audiences. The nature and characteristics of each group should be clearly defined during the instructional design of the programme, and the needs and expectations of each addressed independently during both design and testing of the package.

Time and motion

A photograph is often more evocative than moving footage, but television has trained viewers to expect motion on the screen, and the pace of TV is getting appreciably faster as viewers grow more visually literate and demanding. The complexity of some displays in pop music programmes is positively frenetic, with dynamic layers of text and pictures changing all over the screen.

Peter Lewis, of the British Golf Museum, observes that 'The time spent watching an AV is deceptive. When I went to one museum to look at their use of touchscreens, I thought that the AVs were lasting about three minutes. Then I started to time them, and they were actually lasting between 70 and 90 seconds.' He says that, 'On average, [museum visitors] only spend something like five seconds reading a text panel'.[1]

Lewis aimed to keep the audio-visual sequences in the Golf Museum to 'About 60 seconds – my simple guideline was that no script could fill more than a single page of double-spaced paper ... [but] I eventually discovered that professional actors read more slowly than museum directors, so most of the AV are actually about 70 seconds long.'

The values which inform the pacing of screen displays are amply demonstrated by documentary television or news magazines such as *Newsnight* in Britain or *60 Minutes* in the US. Many brief interviews present, piecemeal, information which the reporter could deliver straight to camera, but a variety of talking heads lend both authority and diversity to the presentation. Voices are disembodied, to start before the face is seen, and continue after the screen changes from a close-up of the speaker to a location shot or graphics.

- Opinion varies, but a good rule of thumb for a picture essay supplies a fresh image every three seconds, and rarely runs one segment of moving footage for more than 45 seconds at a time.
- Separating audio and video, and interpolating other sound and images, can help to vary the presentation of a long segment of audio-visual material.
- Where still images deserve closer inspection, creative rostrum camera work – that is, scrolling and panning – can engage and sustain the viewer's attention. Slowly moving across the image, or concentrating on its details and then drawing back to reveal the whole, may help the viewer to appreciate features which are lost on a single screen, and can create any number of screens from one static source.

Creative screen displays can also do much to encourage the viewer to pause and appreciate still images. An image may be framed by a decorative border or enhanced by captions and commentary; text displays may be optional, and presented on sub-screens or in pop-up labels only as the user requests them. This, too, helps to make the screen image dynamic.

Equally, essential information can be transferred from one medium to another – one striking still frame may convey the essence of a film clip, or audio alone may represent a speaker's views as well as a talking head. Images supplied in video or photos can be

rendered in graphics which may convey the essential message more directly to the viewer. A silhouette or a drawing may be more technically efficient than a photograph or three-dimensional image – and have the impact of novelty as well.

ERGONOMICS

CD-I systems are likely to be used in a variety of environments from the desktop to the family room. Where a package is commissioned specifically for one environment, designers can easily determine whether users will sit or stand, their proximity to the screen, and the input devices which they will be offered.

Training and education

Technology-based training and education generally presumes that a single user will sit directly in front of the screen or, at most, that a small group will gather virtually within arm's reach. Designers can usually expect to know exactly what input devices, and even what make and model of screen, will be offered.

The input devices are likely to include the computer's keyboard and mouse or trackerball (or rollerball). Some applications will favour a touchscreen or its cousin, the concept keyboard (a touch-sensitive panel with changeable plastic or paper overlays). Some interactive video systems offer each user the choice of a keyboard or mouse, and tailor the presentation accordingly. Some may also include optional output devices, such as printers, and some may also incorporate customized devices (such as real keyboards or control panels from other equipment) in simulations and realistic hands-on training.

When a programme is commissioned for a specific organization, all this information should be included in the contract documents. Where a training product is being published commercially, developers are advised to undertake some research to determine what delivery systems are already in use within the target market, or what the target audience is most likely to buy on the basis of current use and past experience.

Information systems

Information systems – in tourist centres, museums or shopping malls – are also likely to attract users directly to the screen. Museums occasionally encourage visitors to sit

with the system, but most information services in public places encourage throughput by obliging users to stand.

Where many visitors are likely to be children, screens may be low, or at different heights in different locations. A customized keypad or touchscreen can be both simple and hard-wearing; some products even claim to be vandal-proof or at least ruggedized for such an environment. The mouse and keyboard are usually avoided, being intimidating to new users and vulnerable to damage, and even joysticks and tracker-balls – also tricky for new users – can be incapacitated by hard use and chewing gum.

Most information services scatter delivery systems as widely as possible throughout the display area, store or museum. In a building with several floors or rooms, each system may present material relevant to that location, either primarily or exclusively. Many displays combine interactive terminals with larger slave monitors. Sound, of course, can be a problem here, as can the confusion between the live and passive monitors. (The interactive systems in the Bank of England Museum, for example, were installed in a room with such low ceilings that tall visitors could touch the slave monitors, not realizing that only the terminals below had active touchscreens.) Clear signage and good design of course can help.

Hoods, partitions, telephone receivers and headphones can variously direct the soundtrack to individuals or small groups. However, many marketing and museum presentations opt for total silence instead, both to reduce the ambient noise level and spare staff who may have to listen to the presentation many times every day (and who may just turn it off if they get very bored or irritable). This puts particular onus on the visual design, if there is no audio to complement it.

Consumer products

The designer of consumer products faces many challenges. The CD-I system might be used by a group playing a game in the living room, or an individual studying in a bedroom or office. Users will receive the standard hand-held thumbstick remote control unit with the system, but can add a keyboard, joystick or other input device, which various manufacturers will supply to the new market. In designing and testing CD-I applications, it is useful to assume that:

- Everything on-screen should be legible at a distance of three metres or ten feet.
- If the display is legible within the safe area of a 50cm/19 inch NTSC monitor (and, ideally, a 35cm/14 inch screen as well), it will then be legible within the slightly different PAL and SECAM and multi-standard monitors.

- Most interaction will be effected through a hand-held remote control device (either the standard thumbstick controller, or a similar product).

A well-proportioned screen display never looks too large, while a crowded screen can never be large enough. A critical analysis of presentation aids at professional conferences illustrates how well-designed images are equally attractive on huge presentation screens and small local monitors, while densely-packed text and images can be illegible even on screens which reach from floor to ceiling.

ESTABLISHING CONVENTIONS

The design of any project, from a single commission to a series of commercial titles, should begin at a conceptual level, with the style sheets which establish visual and navigational conventions for every part of the package.

These are simply a form of the standard practice instructions (SPI), common to many professional environments. They may be called standards, practices, conventions, style sheets, models, rules, exemplars or guidelines – one of the first tasks is to choose an appropriate term, and to use it consistently.

These instructions necessarily combine hard and fast rules for common features of the design, and explicit but flexible guidelines for less predictable elements. They typically address functional questions such as the appearance of text on the screen and the use of colour-coding, as well as conceptual issues such as navigation, interaction and audio-visual style. It is best to experiment with real screens (and, ideally, real users) to establish these conventions, but no detailed design work should go far without the firm guidance of a style sheet.

It is absolutely essential to establish a set of uniform guidelines before embarking on a long project, or a series of related publications, even if field testing leads to some modifications as the work progresses. Even in a small one-off project, firm guidelines represent a productivity tool which can greatly facilitate the quick and efficient execution of the commission. Guidelines provide a valuable *aide-memoire* even where all the design is in the hands of one person, and an invaluable model where many people are working simultaneously on different parts of the design – especially where freelancers or external suppliers are commissioned. And, once established, the guidelines for one project can easily be adapted to create a new visual style for another.

Publishing and broadcasting

Style sheets are hardly unique to multimedia – journalists and publishers in all media use style books which adjudicate on practical matters such as variant spellings or the use of abbreviations, and provide guidelines on the correct use of words and stylistic devices. Many non-fiction publishers have both general guidelines and a range of style sheets for the specialized vocabulary of vertical markets such as finance or computing. Several style books and guides for writers and editors (in print and broadcasting) have been published commercially. These provide a useful model for issues such as:

- The correct and consistent use of abbreviations and acronyms, including titles, addresses and names, as well as guidelines for local practice within specific organizations or subject areas.
- The consistent use of text and figures for numerals (typically, in text from one to nine, and figures from 10 upward), including conventions for fractions and decimals, dates, eras, ages, currency, financial and other professional data, percentages, large numbers, and the time of day, as well as the use of Roman and Arabic numerals.
- Guidelines for punctuation, including spacing after full stops or periods, colons and semi-colons, the use of parentheses, dashes and hyphens, and of capitals or upper case letters.
- Advice on literary style, including the use of collective and proper nouns, prepositions, pronouns, variant spellings, jargon and clichés, and 'distinguishables' or 'tricky distinctions' (e.g. disc and disk).
- Basic principles of layout and design which, in guidelines for television and video producers, effectively describe the conditions which CD-I designers should respect as well. Even the guidelines for print provide some useful advice for laying out text screens.

As well as guidelines for screen design, the style books of print or broadcast journalism can also provide good advice on writing for media which demand much the same sharp and concise prose style as interactive multimedia programmes. Simple questions of consistency, and conventions made familiar by other media, are easily overlooked by a busy production team – and easily spotted by a visually-literate audience. A style book off the shelf of a good academic or professional book store will identify the issues to address, and provide models of good practice.

Multimedia

Multimedia environments add another dimension to the question of conventions and standards, particularly under the influence of graphical user interfaces (GUIs) with their icons, objects and other visual devices.

As well as the elements common to all style books, multimedia design typically also should address issues such as:

- The main elements of a visual metaphor, and details of its application to general and specific parts of the programme.
- The names, sizes, weights, styles, colours, justification and spacing of all text fonts, in the specific contexts in which they will be used (e.g. menus, databases or captions).
- The use of colour conventions (including, for example, ranges for background colours and borders, or colour-coding of discrete modules or types of data).
- The design and colour-coding of cursors, icons and graphical user interfaces.

Establishing a grid with clearly-labelled co-ordinates as the basis of all screen design helps to set locations and ratios for different elements on the screen (pictures and captions, for instance, or headlines and bullet points). Design elements such as text and icons are guaranteed to appear in exactly the right place every time, when every member of the team is working to the same grid co-ordinates – a useful feature for objects which recur throughout a programme or series of programmes.

This is another feature of CD-I design which benefits immeasurably from prototyping, and a period of research and development before the main work of the project gets underway. Establishing practicable conventions and guidelines at the outset greatly facilitates the actual execution of both graphic design, and the various stages of production which take an image from source to the CD-I disc.

COLOUR

The phrase '16 million colours' falls easily from the lips of hardware manufacturers, as the arithmetical consequence of supplying an 8-bit palette (2^8) to each range of red, green and blue, the primary colours on which all others are based. This provides an ultimate choice of 256^3 or 16 777 216 altogether.

Strictly speaking, the word is not colour, but hue, and a mere three hues – blue, red and green – in their various combinations provide the millions of variations which we

see all around us. Colour is an aspect of light, and there is a slightly different hue for every discrete wavelength of light. This can be measured scientifically in units as small as nanometres (one thousandth-millionth of a metre), so there are easily millions of discrete hues.

Colour theory

There are perhaps 200 colours in the spectrum, but the Victorian pioneer of colorimetry, Joseph Lovibond, devised a system of glass filters (based on the artist's primary colours of magenta, yellow and cyan), which eventually produced nine million permutations.

In practical terms, however, it would take a highly trained eye to sort out so many discrete hues (and only then if they were arranged in contrasting patterns rather than closely graduated ranges). Training has much to do with any one person's perception of colour – someone who works with colour might distinguish twice as many individual hues in a single image as someone who is relatively indifferent to the nuances of colour.

A short excursion into colour theory would be time well spent by any designer who has not already had that formal training; there are many excellent books on the subject, and any number of short courses from art colleges, museums and galleries. Colour theory is based on scientific principles, and the relationship of different colours in the spectrum (which, arranged as a circular colour wheel, reveals distinct patterns of complement and contrast). These principles explain why some colours will always clash or harmonize in close proximity to one another, how hot colours seem to advance while cool colours recede, and how nearly 17 million hues can be created from the seven basic units of the spectrum.

Most courses on colour theory will also consider the influence of contemporary technology on the use of colour, and the cyclic relationship between commerce, technology and fashion in influencing the use of colour. Technical standards in industries such as print, textiles, chemicals and paints have enormous influence on the use of colour in manufactured goods and refined products; the use of colour in film, video and computing is less influential than subject to fashions set elsewhere, and the limitations of their own technology.

An eye for trends in the use of colour in television, animation, print, packaging and fashion can provide many good ideas, and clues to the changing tastes of a given audience as well. Graphic designers by the nature of their trade tend to be highly sensitive to colour – and to fashions in colour of which their audiences may not always

be aware. The choice of colours for any one purpose usually strikes a balance between immutable colour theory, informed personal preferences and pervading trends and fashions. Tastes in colour shift by the decade, and the prescient use of colour is one of the many small tricks which can extend the shelf-life of a programme. However, designers should also consider the psychological effects of colour, and the associations which accrue to individual hues and combinations.

A certain awareness of corporate design is also useful, both as guide to trends in vertical markets, and as a precaution against using colour combinations which may have strong associations with a well-known organization or product. Conversely, of course, it is sometimes useful to exploit such associations, particularly in scattering a company's own corporate colours throughout work commissioned for them. (Only remember that British Telecom lavished a good deal of corporate blue and yellow on their interactive video packages, before the corporate colours changed to blue and red.)

Choosing screen colours

In nature as in television, colour is a function of hue, saturation and lightness or luminance – the YUV of video and computer graphics, explained more fully in Chapter 7, Audio and Video on CD-I. Each of these is individually controllable, and it is these minute adjustments which expand the three basic hues into the palette of thousands and millions.

The effects of these adjustments can be demonstrated with the colour editing facilities on a computer graphics or desktop publishing package (and, of course, a colour monitor). A standard DTP package typically provides the references for standard colours in the printer's Pantone range, but designers can make also subtle adjustments on the screen by altering the values of individual colour codes.

Some packages allow users to specify and adjust colours using the RGB (red, green, blue) codes of computing, the HLS (hue, lightness, saturation) of video, or the CMYK (cyan, magenta, yellow, black) of print. The results are effectively the same, the choice of terms only illustrates that there are many ways of imposing arbitrary values on information from the natural world in order to process it consistently.

For screen designers, it is important to remember that all computer and video displays *emit* light. Paper, by contrast, *reflects* light – so the same colour reference will produce a different effect in the luminous light of a TV screen, and the reflective light of a book or print-out. Saturated reds and oranges, for example, may appear to 'bleed' into adjacent colours on the screen, where milder colours can be contained within crisp

borders. Strong colours from the hot end of the spectrum (including gold and other metallic finishes as well as combinations of red, orange and yellow) can be too strong to watch comfortably. Blues and greens are generally cooler, but even light or bright hues of these can be strong on screen.

The effect of difficult colours and awkward aspect ratios can be seen on a number of the videodiscs (and, indeed, videotapes) already produced for galleries and museums in North America, Europe and Japan. Some of these discs have vetted images to select primarily those which reproduce well within the limitations of a rectangular screen of luminous light. Others, which provide comprehensive catalogues of large collections, invariably include many which illustrate the difficulty of adapting complex or narrow images, and strong or saturated colours (including gilding) to the screen.

One veteran of the interactive video industry advises: 'Avoid highly saturated chroma and excessively hot video. Keep the working level and key levels as low as a visually-pleasing picture will allow (usually around 80 IRE). A good rule of thumb is: "If it comes out of a camera, the levels should be OK for disc mastering." It's when the red isn't red enough for the client, and you reach for the enhancer, that problems can occur.'[2]

- *CD-I displays favour warm (rather than hot or muted) colours.* However, strong colours can be used effectively in moderation, rather like spot colour in print. A high level of chrominance instantly attracts attention on the screen, and is appropriate for panic buttons or icons which the user may need to find quickly (in a speed test or simulation, for example).
- *As a CD-I disc might be played on a PAL, SECAM or NTSC screen, it is important to check and compare images in all three standards.* The same colour, on perfectly adjusted monitors, will often appear differently in NTSC than PAL or SECAM: PAL and SECAM are fundamentally similar, but NTSC's different luminance values make its displays brighter than theirs.
- *Backgrounds particularly should favour neutral or pastel hues with a fairly low level of chrominance.* A subtle texture can greatly enhance the visual impact of a discreet background, but the shading required to create the illusion of text will demand more colours from the look-up table. Busy or bright backgrounds are simply distracting.
- Combinations such as red on cyan, magenta on green, or orange on violet/indigo, are particularly intractable; vibrant combinations of blue and yellow/orange, red and green, or even strong reds and blues, although useful for psychedelic effects, should otherwise be avoided in screen design.

Colour theory is helpful here, to identify both good and bad combinations. Complementary colour pairs – that is, direct opposites – can be effective at a glance, particularly on paper or fabric, but acute contrasts are distressing to watch on the screen. The eye simply cannot focus on two competing colours in so small a space; this is particularly observable where adjacent pixels in a detailed graphic display radically contrasting colours. However, a small degree of contrast can be very useful to distinguish key words, or identify important objects in a way that subtly attracts the viewer's eye without clamouring for attention.

In video and photo shoots, lighting of course effects the quality of the colours which the camera records. The production team should include someone who understands lighting (in the studio or on location) – typically, a professional colour photographer or the lighting expert of the video camera crew – and can cultivate warm colours with low levels of contrast.

Artifacts and anti-aliasing

The problem of unwelcome artifacts, or electronic debris on the digital screen, is related to that of colour. Automated anti-aliasing software, for example, may reduce the contrast between jarring colours by adding intermediate tones, which smooths the image but increases the number of hues required overall. However, this and other common problems can be obviated by careful design:

- *Extremely thin lines or fine patterns – particularly, single-pixel lines on sharp curves, acute diagonals or narrow stripes – should be avoided in any display for a television screen.* (This is a point to remember in briefing people to appear on camera – striped and checked clothes can create unpleasant effects, too.) Single lines should usually be at least two pixels wide at every point, and refined during post-production to smooth rough edges and stepped curves.
- *Equally, rigid geometric shapes (triangles, circles, squares) tend to be distorted by the convex shape and aspect ratio of the television screen.* This is particularly noticeable where large blocks of strong colour are employed (especially in NTSC). Thus, some of the most common elements of conventional graphic design are inappropriate for screen design.
- As a general rule, monotone line drawings, or graphics which combine a strong outline with blocks of contrasting colour, cause technical problems out of proportion to their aesthetic value.

There are technical tricks to address some of these problems, but the best answer lies in avoiding the cause – avoid stark line drawings, and aim for low contrast or graduated colour spreads in all graphics (again, remembering to keep the colours within the limits of the look-up table or encoding technique).

Colour-coding

Hues in their millions are necessary for photographic images which attempt to reproduce information from the natural world as accurately as possible. However, graphics may be quite complex and still use only a few dozen colours, and a select palette is a positive virtue in many applications.

- By the time colour-coding is applied to visual conventions, the practical range has dropped from the millions technically available to the five or six for which users can reasonably be expected to remember a coded meaning. If colour-coding is used in a programme with many vivid graphics, colours which have a coded meaning must be distinctive, and reserved exclusively for their coded function.
- Even half-a-dozen separate uses of colour on one screen can make for a gaudy and confusing image. Associating specific colours with individual icons or functions, or with specific parts of the screen or programme, may help the user to remember or distinguish coded meanings. (Help functions might always appear in one colour, for example, and subtitles in another.) The help function should include a colour key to refresh the user's memory.
- The use of colour-coding may profitably be divided between data on the screen, and the borders or backgrounds which set off the text and pictures there. Thus, in a training course, menus, instructions, exercises, tests and reference material might be coded by distinctively coloured frames around the edge of every screen, to indicate either the type of material being presented, or the section of the programme being explored.
- At the same time, it is important that text, cursor and background colours are not too close together on the same palette, especially as users may not adjust their sets as subtly as those in the authoring studio. Where a two-part code distinguishes both the type of information on the screen, and the section of the programme in which it appears, it is important to ensure that all possible combinations of coded colour work well together on the screen.
- It is useful, too, to consider the psychological or material associations of colours in assigning codes – red/stop and green/go, for example, are familiar conventions.

(At the same time, where a programme is aiming for international distribution, or an audience with distinct cultural values, research can help to exploit positive associations and avoid negative ones.)

It is also worth bearing in mind that a significant percentage of men in the western world are to some degree colour blind. The incidence of defective colour vision tends to be genetic and sex-linked: the gene is carried by women but usually inherited by men. In most of Europe, the US and Canada, one person in twelve has some form of defective colour vision. This ratio drops by degrees to one in thirty in Japan, and one in fifty amongst the people of the equatorial rainforest and the arctic.[3]

The most common forms of defective colour vision confuse green, yellow or brown with orange and red, and grey with purple. Where defective colour vision is common, one man in twenty cannot confidently distinguish pale shades of these colours. Since red, orange and yellow, as saturated colours, can cause the screen designer other problems, this is perhaps another incentive to favour colour schemes from the other end of the spectrum, or at least to ensure that important colour codes employ hues which all viewers can distinguish.

One interactive video application, the Intelligent Video Learning System (IVLS) which supplies technical training in Ford's Parts and Services Division in the US, actually incorporates software utilities for users with colour-defective vision.

There is one challenge to colour schemes which designers will never control so long as individual users all adjust their own TV sets. Colours vary in brightness according to the quality and adjustment of each television or monitor, so extremely subtle colour differences may be lost on some viewers. The quality of the screen may also affect legibility of text, icons and other essential visual material – just as the quality of the audio system may vary dramatically from one television, monitor or hi-fi to the next.

CURSORS

In CD-I, the cursor plane is restricted to an area of 16 pixels by 16 (which, of course, can move anywhere about the screen), and one of sixteen colours. The cursor may, at the designer's discretion, move smoothly around the screen, within a defined linear track, or be sticky where this improves the functionality of the programme.

Computing has established some conventions in cursor design: an arrow which points upward, or a flashing rectangle or vertical line are common cursor designs in applications software. (British designer Theo Wright confesses that he did not know

that there was a convention – that arrow-shaped cursors should always point up – when he designed his very first programme. Having control panels on the bottom of the screen, and none on the top, he thought it logical to use an arrow that points down, and was surprised at criticism from his newly mouse-literate colleagues.)

Good design strikes a balance between positive innovation and the effective use of conventions. So long as the cursor is crisp and functional, it can effectively assume any simple shape: graphics packages often change the cursor to illustrate a tiny pencil, paint brush, bucket or hand, as the user employs various functions to draw, paint, colour or move graphics. Professional computer software takes a conservative approach to the design and use of cursors. But, as CD-I is primarily a consumer product, the creative use of shapes and colours in cursor design is virtually unlimited.

However, where users point at words or objects to select options and information, unless the targets are very large (as in a children's programme, for example), it is generally useful to design a cursor with only one sharp point, and to tell designers, programmers and users that the point alone effects selection. (A pencil is a useful metaphor here: however long it may be, the lead at the sharp end is the functional part of the object.)

This is particularly important in designing large cursors for use in consumer applications, where the user may be some distance from the screen, or information packages, which may attract a large number of users unfamiliar with cursors. It might seem too obvious to mention, but for the examples already extant of poor cursor design, to suggest that:

- Colour-coding may be useful to distinguish different functions available through the cursor; however, it is generally less distracting if the cursor maintains the same strong but not obtrusive colour throughout.
- The cursor must always be a distinctively different colour from the rest of the screen, so it may change colour or employ a strong outline if the cursor is likely to blend into any one screen and become lost.
- The cursor should be displayed whenever it is active or potent, if only to remind users that they can interrupt or take action when they choose; where the sight of the cursor on the screen is distracting (for example, in a moving video sequence), it may be removed, but it should appear again immediately the viewer activates the input device to interrupt or interact.
- The cursor should not appear to fall off the screen, out of sight of the user, or perform illogical functions such as disappearing off one side and reappearing on the other, as though it had slipped round the back of the set.

- The cursor should usually stay in the same place when the display changes from one screen to another, so the user can find it again easily. In some circumstances, it may be useful to move the cursor automatically to the most logical location for the next interaction – to the edge of the control panel, for example, or the choices in a menu screen.
- The state of the system may be represented by changes in the cursor: if the user makes a selection which requires a few moments' processing, for example, the cursor may change to a clockface, hourglass or similarly familiar metaphor to indicate that the system is preparing information which will be presented shortly.

The guiding principle of cursor design and use should be convenience to the user, who ought never to struggle with finding or controlling anything so essential as the cursor on the screen.

ICONS AND OBJECTS

Much of the same common sense applies to the design of icons, objects, hotspots and other elements of the graphical user interface as to cursor design. Logical and consistent use of conventions such as colour-coding, graphic style, size and texture, highlighting and lowlighting, apply equally to icons and objects.

Icons tend to be small, simple graphics which act as *aides-memoire* to remind users what data or actions are available at any one time, and then to effect these. In the Apple Macintosh environment, for example, documents may be represented by a tiny icon of a single sheet of paper with a folded corner; to delete a document, users simply drag the icon, using the mouse to select and move it, to another icon representing a trashcan (US) or wastebasket (UK). The dustbin icon is the same in both countries, but the text label beneath it changes in deference to local practice – an interesting aspect of icon design that effectively illustrates both the advantages and difficulties of graphical user interface.

Objects tend to be larger, and often have more complex, dedicated functions. The same icons may recur throughout many software packages and applications; objects tend to be designed specifically for highly specialized jobs within any one presentation. An icon stands out from the rest of the information on the screen; an object typically forms part of a larger graphic, in which it acts as a visual metaphor for an action which can be effected by activating a hotspot there.

Icons and objects can be of virtually any shape, size or appearance but they must clearly represent familiar symbols if they are to suggest practical associations to the user.

- Ideally, users should recognize the implicit meanings of icons and objects, rather than have to recall them from previous instruction or experience.
- Icons are usually rendered in profile, or as line drawings in a single colour, so it is important to choose a meaningful symbol and draw it well.
- A tiny, detailed icon simply presents the user with an unintelligible image; where there is ambiguity, a text label or audio prompt may help, but another model for the object would probably be better.
- The whole of an icon or object should be active, so that the user has only to touch any part of it to effect an interaction. Where the object is of an irregular shape, a uniform area around its extreme edges should be identified as the hotspot, so the user is not frustrated in trying to find the active area of the object.
- Colour and texture can be used effectively to convey visual clues. Objects which perform special functions, or lead to other parts of the programme, may move, shine or sparkle or otherwise draw attention to their special status.
- Similarly, a distinctive visual style may distinguish hard-edged, strongly coloured objects, which users may employ, from purely decorative details in a softly drawn and coloured picture.

Of course, the function represented by any one icon or object may not be relevant to every scene in the programme. Colour-coding can identify which options are available or appropriate at any one time. On monochrome computer screens, for example, this is usually effected by displaying inoperative choices in grey, and active ones in black. Alternatively, the control panel may toggle between two sets of icons in the same format, with only the active choices displayed at any one time.

As a general rule, it is preferable to display the same arrangement of icons or menus every time, and to disable those which are temporarily out of service, rather than rearrange the active elements, or leave black holes which may distract or confuse the user. Consistent displays help the user to grasp the conventions and functions of the programme, and form a Platonic image of its essential features. It is easier to perceive at a glance that certain functions are temporarily disabled, than to appreciate why the layout of the screen has changed from one segment to another. Appreciating why any one feature may not be appropriate in the context can also help the user to learn something about the functionality of the programme or its subject.

TYPOGRAPHY

The general enthusiasm for graphics of all kinds has tended to overshadow the enormous advances in typography which screen designers now enjoy. The limitations of computer text persisted well into the eighties, but advances in a range of related software applications have now given screen-based designers as large a repertoire of graphic resources as conventional typographers.

Many suppliers offer not only alphanumeric fonts, but also the decorative devices known in the printing trade as dingbats, and a prodigality of borders, backgrounds and graphic images known to the computer trade as clipart. The immediate consequence of this new affluence is sometimes observable in layouts of the type which printers used to call circus make-up. Once the novelty has worn off, though, many designers still find use for a number of fonts and effects within one programme.

Decorative and useful

Typography is as vulnerable to fashion as any other aspect of design. Nothing typifies art nouveau or the swinging sixties more than their characteristic tastes in typography. Equally, 'never mix, never worry' was once the ground rule for the choice of serif or sans-serif fonts (that is, those like Times, which have little decorative flourishes, and those like Helvetica, which are undecorated). Now, the rule is virtually reversed, and bodytype in one style is often complemented by headlines and captions in the other. This is one simple way of establishing useful conventions which do not materially effect the contents of a programme.

The technical aspects of creating screen text are described in Chapter 11, Programming. Some conventions are useful in designing text for the screen:

- A unique typeface helps users to distinguish supplementary information – menus, indexes, glossaries and help screens – from the main contents of the programme.
- A combination of fonts can enhance a screen full of text, and help the user to distinguish at a glance between the main text, and the variety of headlines, subheads and captions which help to identify individual segments.
- Nonetheless, more than two or three fonts on one screen – and more than five or six in an entire programme – is usually more than the design or conventions of the programme, or the end user, can comfortably accommodate.
- The consistent use of typographic features such as weight (e.g. **bold** or *italic*), devices such as bullet points • or distinctive initial letters can draw attention to

important information. However, many of these effects look better in print than on TV – colour-coding often makes a better substitute on the screen.

- The restrained use of boxes, borders and backgrounds is useful both to make a text screen more attractive and inviting to read, and to supply coded information about what it contains, or the part of the programme in which it appears.
- Discrete use of capitalization, or UPPER and lower cases, not only supports more useful conventions, but also helps most people to read faster. UPPER CASE or ALL CAPS is certainly arresting, but the variety of letter heights, widths and shapes in the lower case provides subconscious cues for experienced readers, who recognize common words or letter combinations by their outline. (Only try reading a learned paper, rich in esoteric terms, to observe how the eye skims through familiar words and stops to decipher new ones.)
- However, the uniform application of the upper and upper-and-lower conventions is a useful feature to establish appropriate styles for titles and headings, to distinguish text screens at different levels or layers within the programme, or with different functions within any one layer or module.
- Conventions such as colour-coding, or the use of capitalization, particularly help to distinguish KEY WORDS within the text which effect hypertext links between databases – for example, to point-and-click on a personal name, and immediately see a potted biography of that individual, or to select a technical term and move directly to the glossary entry with its definition.
- It is particularly important that viewers can immediately distinguish between similar screens, particularly when something has been added to a text screen as a result of an interaction. Colour-coding, a different size or weight of font, or effects such as flashing text can be valuable here.

None of these devices is strictly necessary – but all can contribute significantly to the comfort and ease with which the user moves through the programme. Just look at a well-designed page in a magazine, for example, and consider how much information the reader can grasp at a glance merely by the creative and consistent use of typography.

Text on the screen

Magazines, of course, are inherently typographic: the written word is their main business. They also come in a variety of shapes and sizes, although virtually all take on the portrait format of taller-than-wide. Screens, although they may vary in proportion, are virtually all landscape, and wider-than-tall. They, too, come in a variety

of sizes, but the text in a recorded programme is proportionately the same on a small TV monitor or 36-screen videowall. Modern TVs and video monitors are now standardized with an aspect ratio of 4:3, but the new letterbox format of high-definition television is wider and narrower, with an aspect ratio of 16:9.

Some few designers, working with a network of uniform delivery systems, know the exact size and model of the screen on which their work will be displayed. Many must assume a worst case which may take the same display from an office workstation to projector in a conference hall.

The screen is a rigid environment for typography, compared to the open spaces of a newspaper. Fonts and designs which look attractive on paper may not work nearly so well on screen. The only way to know for sure is to test prototypes (ideally, in front of representatives of the target audience, rather than colleagues who are already too used to reading data from screens, or designing them).

Features to watch in evaluating the effect of different fonts on the screen include not only the basic legibility, and general aesthetic effect, but also:

- Spacing between letters, words and lines – too much is as distracting as too little. As a rule of thumb, a space equal to half the font height (measured between the bottom of descenders such as ‘g’ and the top of ascenders such as ‘h’) makes for a balanced, legible display with a paragraph. The full height of the font effectively separates units such as paragraphs, headlines and subheads.
- Overkill – three or more fonts may be necessary to separate all the information on a newspaper page, but three is absolutely the limit for the average screen unless a neo-Victorian effect is positively desired.
- Distance – users at a workstation or information point will probably sit or stand directly in front of the screen, but those at home will often sit some distance away, as though watching television.

It is also important to remember that all letters are not the same width:

- Individual font designs vary, but ‘m’ and ‘w’ are often twice the width of most other characters in the same set, and the five letters of ‘flirt’ are usually half the standard width. All text, therefore, benefits from the judicious application of proportional spacing which is, fortunately, now automatically supplied by most DTP and graphics software, and which can usually also be adjusted on screen to help space and balance the text there.
- Some combinations of letters (‘Ye’, for example) also require an additional service, called ‘kerning’, to make fine adjustments between characters of signifi-

cantly different shape. Where this facility is lacking, it is often easier to sense a discrepancy than identify its cause: minute adjustments, by hand, may effect significant improvements.

- In many DTP and graphics packages, these two features can be manually adjusted by the designer, either by changing the default settings for all the text produced in a particular style, or by tweaking specific screens (particularly, those with a few words of large text, where flaws which are normally imperceptible are suddenly exaggerated.)

A laser printer in a desktop publishing system usually has a resolution of 300 dots or lines per inch (dpi); in a design studio, this may be increased to some 1200 dpi to produce sharp camera-ready copy for printing. Type is measured in points (72 points to the inch) and picas (12 points to a pica, six picas to an inch). Thus, the ten-point text on this page would comprise 42 lines of graduated detail even at a resolution of 300 dpi, and has actually to be processed at a much higher quality.

The very smallest text in a CD-I system is about eight screen lines high so, obviously, the resolution is much lower even than that of an office-quality laser printer. Text less than, say, 15 lines in height usually requires special attention to ensure that it is encoded legibly on the screen.

- Fonts of less than 11 points or 11 pixels in height are generally too small to read comfortably on the television screen – particularly from a distance, whether in the living room or the training centre.
- Small or complex fonts, and special effects (such as shadows, embossing or other textures) are best created with the text facilities of a good computer graphics package. This computer-generated text is treated like any other detailed image during the authoring process.
- Text can also be written to the screen at run-time, using the CD-I system's own text display facilities, which support fonts of any size, with one to four bits per pixel. Run-time text can be slow, particularly if the font is small or complex in design; CLUT 7 encoding with a limited range of colours (or a dynamically-updated range of look-up tables) is the most efficient option.
- All text should be optimized during editing (typically, with anti-aliasing to smooth diagonal lines and curves).
- Anti-aliased fonts demand CLUT 7 locations for every colour, and at least three bits per pixel; backgrounds to anti-aliased fonts may also have to be smooth rather than textured, given the range of colours available.

- In 'single pixel fonts' with very slim lines and curves, CLUT 4, CLUT 7 and DYUV encoding offer the higher resolution which improves their display; text sub-screens in double or high resolution can of course be combined with larger images at normal resolution.
- Low contrast between text colours and backgrounds reduces the effect of undesirable artifacts and renders text more legible.
- Tastes vary but, as a general rule, proportional spacing and ragged lines minimize unpleasant effects in text displays, so languages which read from left to right should be set with a justified left margin and ragged right, and those which read from right to left, set with justified right and ragged left.
- Brief text screens and headings often look more balanced if they are centred, either on the screen as a whole or within the frame of the text display – it is important to choose the right parameters to achieve a pleasing effect.

Of course, the essential dilemma in screen design is the aspect ratio of the television. We are used to seeing TV in a horizontal format about four units wide by three units tall. Movies do not always fit this screen, but there's a certain cachet in adding black borders to the top and bottom of the screen to accommodate (or suggest) the wider aspect ratio of 70mm film. The real problem is text: virtually all written material from letters to newspapers is taller than it is wide, and for good reason – many short lines are easier to read than a few long ones. No display which is wider-than-tall can disguise itself as a book, and screen designers must adopt strategies appropriate to their medium.

WRITING FOR THE SCREEN

The screen is a small palette, even when it fills a wall at the front of a lecture room: a common fault in presentation aids of all kinds lies in trying to display too much text at once. A screen full of text can be overwhelming even to highly literate viewers: we are so used to the conventions of film and television that we feel under pressure to read the whole screen quickly, before it is snatched away. Reading from a screen is tiring, even with a word processor or database which is designed to display little or nothing but text. Many screens chock full of text can be off-putting even to the motivated user.

How much is too much is partly dictated by the conventions of film and television. The first film-makers designed their inter-titles for audiences who were not always highly literate, and who were initially unfamiliar with the conventions of interpreting text and pictures separately.

Not much has changed, for aside from captions and sub-titles, audio-visual presentations (including television documentaries) still tend to alternate visual and textual information. Nor can designers always know how comfortable their audience may be with the written word. Literacy may be expected but should not always be assumed, for although total illiteracy is fairly rare in the industrialized world, functional illiteracy is only too common. Many people who can pick out key words in signs and directions, cannot read a newspaper – and it is exactly this audience who can benefit enormously from interactive systems which allow them access to information which does not depend on the written word. (This group, too, comprises a large number of people who are highly visually literate, and quick to pick up visual conventions, which may supply them with more information than the words which accompany them.)

Quality, not quantity

The quality of the text on the screen is the responsibility equally of the scriptwriter and the graphic designer. Before the designer even sees the script, the writer can do much to ensure that material for text screens is as clear and concise as possible.

The writer's first job is to determine what information should appear as text (rather than dialogue or commentary, for example), and what form that information should take – captions, sub-titles or text screens. The designer can do much to enhance the text, but many important decisions lie with the writer.

- By the final drafts, the writer should be working literally for the screen, reducing the textual material to short segments which can stand alone on a single screen, with many headings and sub-headings to identify individual screens at a glance.
- If every text screen can have a unique heading or title, so much the better, for each is then easily identified, and the chance of confusing similar screens is reduced.
- Designers are divided on the question of how many words fit a screen, but many would say '50 at most' – which is precisely the length of this bullet point (and, many writers would feel, no length at all: terse Hemingway is a better model than rhapsodic Proust for the screenwriter).
- Equally, 50 characters to the line is about right. (That is, the length of the last sentence exactly, not forgetting spaces and punctuation marks.)
- Particular attention is required to produce multi-lingual programmes which respect the demands of every language. Scripts for inherently verbose languages may have to be more tightly written than those for languages with shorter words and less complex structures. This requires co-operation between the translators

or writers for each script, and with performers, designers and programmers, to ensure that all text screens are well spaced, and all audio tracks smoothly paced. It may also require a slightly different program to synchronize sound and pictures separately for each language.

Rhythm and balance are, nonetheless, as important to the miniaturist as to the Proustian, not the least to engage and sustain the audience's attention. However, the use of short words in favour of long ones has two advantages here:

- Short words are not only easier to read, they are easier to lay out on the screen. Many long words present the designer with the choice of unsightly gaps between words on a single line, an awkward array of long and short lines, or hyphenations which are both unsightly and confusing to the reader (and, therefore, to be avoided absolutely).
- Too many short words and sentences make for dull reading in a book, or stilted conversation, but text screens are more akin to instructions than prose, and need not suffer from brevity.
- Nor is a degree of repetition necessarily a stylistic fault: every screen should make sense by itself in every context in which it might appear. Thus, some information may need to be repeated from screen to screen where any one might appear on its own in some circumstances.

This is where testing, and testing again, is essential – to discover every way in which a user might come across any one piece of information, and tailor that screen or segment to suit all potential interpretations. The writer needs considerable conceptual abilities here, or a steady supply of novice readers, to determine what the user may or may not know, or need to know, at any point.

CONSISTENCY

One key to good screen design is consistency: once its conventions are established, the user should be able to navigate within the programme without a second thought for the basic functions of common icons or menus. And the conventions should be relatively few, if the user is not to be confused and intimidated from the outset.

If the programme grows more complex at deeper levels – as many reference works or games typically do – then the conventions may grow with the user's confidence and experience. A local lending library is easier to use than a large central reference library,

for the casual reader just wants to browse and select books from an open shelf. The serious researcher who learns to use a reference collection is rewarded proportionately as more archives and catalogues come to light. Interactive systems can legitimately employ similar principles.

The irony is that the most successful routines are those of which users are effectively unaware. The conventions employed in a reference work – tables of contents, notes, bibliographies, glossaries, indexes – are so familiar that those who regularly use them hardly think of this as an acquired skill. Yet the display of any of these devices varies widely from one work to another – the elements are essentially the same, but their functionality can be enhanced by creative design. Consistency is important in many aspects of screen design:

- *Hotspots which appear throughout the presentation should be located in the same place every time, so that the user can find important functions quickly and easily.* These typically include help facilities, the main and/or last menu or screen, the glossary or index, a map of the programme and, where appropriate, the exit.
- *Information of equal or comparable value should be appear consistently.* This may involve a combination of codes – all module headings may be set in the same font, for example, to distinguish the first screen in a module, with each set against a colour-coded background to identify different modules at a glance. The same coloured background, with text of a different appearance would then identify another part of the same module.
- *The same type of information may also benefit from the consistent use of one presentation style.* It may be creatively or technically attractive to provide help with narration in one segment and text in another, but if the user is trying to perceive a pattern, mixed signals may just be confusing.

Consistency is essential to functionality, but it should not be an excuse for boredom, nor a cue for keyboard mesmerism, where the user is hypnotized into pressing the same key again and again just to see the screen change, without absorbing any of the information unfolding there. (A simple trick here is to move the hotspot to a different place on every screen in a series, so the user at least has to look for it and cannot page through automatically.)

FIELD TESTING

A brief foundation course in behavioural psychology, learning theory, screen design and colour theory sounds like the work of a lifetime, but could be initiated by a few days in a reference library. These are all well-established disciplines which have produced good general guides to their main findings and beliefs.

Designers do not need a profound understanding of communication theory or behavioural principles, but an awareness of the most-widely held ideas and current trends in these fields will contribute greatly to the ability of everyone in the multimedia team to communicate effectively with people through technology.

Equally, research and observation are essential to the designer's own professional development. Draft material, screens and segments should be tested regularly, ideally with fresh volunteers whose previous experience of the subject or technology is similar to that of the target audience. However stylistically or pedagogically sound an idea may seem to the production team, the views of typical users may reveal unexpected insights into the ways in which the real market receives the new conventions of interactive multimedia.

Notes

1 Peter Lewis, British Golf Museum, speaking at the Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.

2 Jere Pichotta, 3M Optical Recording Technical Service, 'Common Master Tape Problems', *The Videodisc Monitor*, July–August 1990.

3 Varley, H. (ed.), *Colour*, Marshall Editions, London 1980.

11

Programming for CD-I

In the established disciplines of computer-based training (CBT) or interactive video (IV), a variety of proprietary software products help qualified computer programmers to work more efficiently, and allow authors without formal training to create interactive programs. The CD-I market is beginning to see tools which at least facilitate the most basic activities, and even obviate the need for formal programming. This chapter considers programming issues and authoring products for the CD-I environment.

PROGRAMMING FOR INTERACTIVITY

The successful interactive multimedia presentation, which appears to flow seamlessly from start to finish, of course comprises any number of discrete modules which might appear quite as effectively in a different order. The key to interactive design and programming is a modular structure which provides optimum use of storage space and processing power on the disc and within the player.

One publisher of computer games, John Garcia of Novalogic, reckons that 'Program code now only makes up about 0.3 per cent of the data on the average disk. Paradoxically, software engineering resources are still the most significant hurdle in making a successful computer game'.[1]

The proportions may be different in other applications, but the message is the same – whatever the creative, intellectual and visual content, successful interactive multimedia presentations depend equally on good programming. Close co-operation between designers and programmers is essential to create an interactive program that is both efficient and responsive. The critical feature of real-time interactivity is, of course, that users' actions can never be wholly predicted.

- Wherever possible, it is useful to arrange related data in a cluster of small files which can quickly be retrieved and processed in various combinations.
- Many smaller economies can also be effected in real time – for example, by using spare capacity to pre-load non-real-time files while real-time data are streaming off the disc, or by re-positioning the pick-up head while the system is waiting for the users' response.
- It may also be possible to use these pauses, awaiting users' response, to seek and open the files which are (or are most likely) to be required next, and even pre-load data which users are most likely to want at any one decision point.
- However, even within a didactic presentation (where students typically have a limited number of choices at any one point), it is not always practicable to pre-load all the data for all the potential options. Response times can be retarded particularly if all the buffers are loaded in expectation of one response, and the user (quite legitimately) takes a more unusual route.

In a disc which combines many facilities, the viewer may suddenly decide to interrupt a picture essay, and play a game instead. Data with no intrinsic relationship may be stored anywhere on the disc, so response times depend mainly on efficient structure and organization to load and process new information quickly, wherever it may be found.

- Audio and video need not necessarily start simultaneously; overlapping sound from one scene with images from another is, of course, an effective television technique familiar to most viewers. In CD-I, the smooth transition from one segment to another can be effected by presenting sound and pictures as soon as each is ready, the first masking the longer time taken to prepare the second.
- Ultimately, consistency is usually more important than speed to ensure that users are not disconcerted by erratic differences in response times. Users may understand that it takes a few moments to switch from a picture essay to a game, but they may also worry or make invalid assumptions if one question-and-answer routine takes longer than another for no obvious reason.
- It may occasionally be worth replicating data which will often be used, so that copies of essential files are immediately accessible from all parts of the disc.

Versatile, modular programs ideally allow the system to load and process only the information immediately demanded by the application. As the presentation unfolds, the player's memory banks are constantly refreshed with appropriate data, to make optimum use of all resources and, particularly, to effect the fastest possible exchange of diverse information between the CD-I disc and its audience.

Programming in CD-RTOS

The CD-RTOS operating system is modular, both to support the demands of interactive multimedia, and to provide an easy upgrade path in a rapidly changing market. CD-RTOS has a number of special features which programmers must appreciate.

- The modules within a CD-I program comprise both conventional program code or constants (i.e. values which do not change), which are loaded from disc, and data modules, which are created dynamically to accommodate variable information during the course of the CD-I presentation.
- CD-RTOS can arrange files to any depth within the hierarchical structure. However, as this could occasion impracticably long file path names to trace descent through many layers, CD-RTOS also provides two default directories. Files which are opened to initiate activity are contained within an execution directory, while those which are not executable are held within a data directory.
- CD-RTOS can start processes with a chain command (which replaces the current process with a new one), or a fork command (which introduces a new process but leaves the last one still running). The parent can assign a process number and priority to the child, and specify the I/O paths which it will inherit, the contents of its parameters and extra memory for its stack area.
- CD-RTOS is a multi-tasking system which does not employ memory management, but allows programs to run anywhere in memory. When a new process starts, most of the registers in the main processing unit are set to significant values, including stack and static storage pointers, so that the operating system can simply point programs to the appropriate locations. Programs must be position-independent and assume that modules and their variables may be located (separately) anywhere in the memory.
- In this environment, access to available memory stacks can be obstructed by blocks still engaged in other processes. The best way around this is to employ a system call which allocates blocks of memory wherever space can be found.
- In CD-RTOS, the synchronization essential to real-time presentations is often effected through signals which interrupt the current process and pass control to the process's signal handler. The process can supply the operating system with the address of a function which directs the response to the interruption. A process can also mask signals which it does not wish to answer immediately, or at all. Signals may be sent from file managers, or between processes.
- CD-RTOS generally employs a consistent interface to all input and output devices. A program must address a new file or device by name to open it for the

first time; however, this establishes a path number directly to the specific file or device, which the program can use subsequently without needing to know anything else about the destination. (The program can, of course, learn more about the I/O path, but direct access can sometimes effect significant shortcuts for the programming.)

Many distinctive features of the CD-I programming environment are reflected in the three central file managers introduced in Chapter 6, CD-I Discs and Drives.

Compact Disc File Manager (CDFM)

The principal challenge for the CD-I programmer is to ensure that data can be retrieved and processed as quickly as possible, to meet the many demands of interleaving and synchronization. Typically, this represents a judicious combination of real-time and other data, and particularly involves the features of the Compact Disc File Manager, which controls the flow of information from the compact disc.

- Real-time data, particularly audio, must be laid down in strict patterns, and tagged with real-time attributes to distinguish them from ordinary records.
- As a file may contain data of all kinds, ordinary data can be conveniently stored in the spaces within real-time files to make optimum use of storage and processing resources. Once the audio-visual and program-related data are arranged, it is more economical to fill any remaining sectors with non-real-time data than waste them on blank padding, the only purpose of which is to regulate the flow of the real-time records.
- The arrangement of directories and files is a question of personal preference or local practice, but should be practical and consistent; one approach, for example, would contain all the data for a single segment (lesson, game, whatever) in a single directory, with audio, video, program-related data, and program code, in separate sub-directories.
- CD-I employs conventions for file name extensions: .d or .dyuv for DYUV images, .clN for CLUT 8, CLUT 7 and CLUT 4 (where N is 8, 7 or 4, respectively), saN for stereo, and .maN for mono audio (where N represents Levels A, B or C), and so forth.
- The Compact Disc File Manager reads all data in the same way unless specifically requested, through a CDFM Play Command, to recognize and honour real-time attributes.

- Once the Play Command is initiated, data flows off the disc as fast as the system can retrieve it. The Play Command distinguishes CD-DA and CD-I's audio, video and program-related formats to direct data to appropriate channels, memory banks or processors, but does nothing to control the data transfer rate. Only the arrangement of sectors on the disc can ensure that real-time records are delivered smoothly to appropriate destinations to support a synchronized presentation.
- Data flowing through various streams can be tagged or marked for synchronization, a technique known in CD-I terms as data-driven action tagging.
- Seek times may be shorter toward the centre of the disc, but the relative proximity of data in separate locations is ultimately more important than their actual position on the disc (as Chapter 6, CD-I Discs and Drives, explains).

The challenges of interleaving and synchronization of course depend on the variety of data in any one presentation. To play music alone requires as little as one command to open the appropriate audio file, and another to initiate a play command to identify these data as real-time records and send them directly to the audio processor. This would leave the player's micro-processor free to do anything which does not interfere directly with the disc or audio processor – for example, to run a simple display of text or graphics already loaded into memory.

However, real-time records usually combine interleaved sectors of audio, video and program-related data such as text or hotspots. To effect the synchronized presentation of this diverse material, real-time records also usually contain commands, and time codes or other triggers for synchronization, which provide the delivery system with the instructions it requires to perform efficiently.

- Every real-time file begins with a Real-Time Control Area (RTCA), which stores commands to direct the playing of real-time records, loading and unloading of audio and video data, audio output, and the handling of drawmaps. These commands can be executed sequentially, in parallel, or in a combination appropriate to the presentation at hand.
- These commands are decoded by a Real-Time Record Interpreter (RTRI), a multitasking interpreter capable of handling many tasks in parallel. RTRI is not conspicuously fast, but it makes efficient use of CD-I's resources by loading and unloading many small discrete real-time records together with the instructions which concern them.
- Because data are demanded randomly in real time, instructions in RTRI do not follow the predictable sequence of many computer programs, but respond to

triggers which act like cues to waiting actors. Each instruction responds to its trigger signal, to join a volatile queue waiting for execution. RTRI's basic instruction set encompasses most common functions, and can be extended simply by adding customized functions for specific applications.

- Real-time files are retrieved through a Play System Call which selects individual sectors by their file number, data type (audio, video or program-related) and channel number (i.e. 0 to 15 for audio, 0 to 31 for other data).
- Within the Play System Call, the Play Control Block (PCB) de-interleaves the real-time data, to separate audio, video and program-related sectors and send them to the appropriate processors or memory banks.
- The Play Control Block refers to individual Play Control Lists (PCL) for each type of datum. The programmer must understand this complex activity in detail; simply put, each entry in these lists describes the control and status fields, points to the appropriate buffer for the data, and to the next PCL entry.
- The Audio PCL provides a channel selection mask (i.e. any set of channels from 0 to 15) to determine whether audio should be sent directly to the processor, or to a soundmap in one of the two RAM memory banks. The Video PCL directs graphics to the appropriate drawmap; the Data PCL sends program-related data to the appropriate area in the player's memory, for processing.
- A program may control Play Commands through the Play Control Block, but the actual activity takes place within the Compact Disc File Manager as an operating system service provided to the program by the file manager. Again, this brief description paraphrases a much more complex activity.

Each entry in the Play Control List also includes a signal number which the CDFM can send to the program when the Play Command ends, or should it encounter a trigger on the disc or a buffer which is temporarily too full to take any more data. Data may easily flow toward the buffers faster than the system can process the information already available.

When a buffer is full, the CDFM points to the next entry in the PCL to find an empty buffer and thence, if no buffer is free, directly to the output processor. This is really only practicable for audio which needs less preparation than other data; the solution lies in providing at least two entries in each PCL so that the CDFM can be filling one buffer while another empties. These entries can be linked to form a loop, which directs the CDFM around all the available buffers, while the program follows in tandem, emptying each in turn.

User Communications Manager (UCM)

The User Communications Manager is principally concerned with input from a pointing device (typically, the base case's hand-held thumbstick controller) and optional keyboard, and output to audio and video devices.

- The pointing device is controlled in a manner familiar in computing environments. At any given moment, the current screen co-ordinates can be supplied through a function called PT-Coord, which CD-RTOS usually employs only as often as new information is needed. A program can instruct the UCM to poll these co-ordinates at an appropriate rate when the pointer is in motion, so the system might track a swift movement 20 times a second, register less data for a slower movement and none at all when the pointing device is idle.
- The UCM also directs the cursor which represents the pointer on the screen, controlling its shape, colour, location, blinking and even its presence or absence at any given moment. The management of the cursor is not unlike that in other computing environments. CD-I's cursor plane could of course support any moving shape which could be contained within a block 16 pixels by 16, in a single colour from a choice of 16.
- The keyboard also functions in a familiar way, with data passing to a keyboard input buffer. When input from the keyboard is expected, for example, the program can issue a read request and simply wait for data; alternatively, the program can ask the UCM to send a signal whenever keyboard input arrives. The program can also ask UCM to determine how many data are in the buffer, either to start reading, or to wait for more input.

It is the handling of audio and video that distinguishes CD-RTOS from OS-9 and other familiar operating systems for a conventional computer environment.

- Audio functions provide volume, panning and balance control, plus attenuation for all the paths in the audio processor (left to right, right to left, left to left and right to right), and the facility simply to turn off the audio processor.
- Most of the UCM audio functions concern soundmaps (described in Chapter 7, Audio and Video on CD-I), which are usually generated through CDFM Play Commands. The UCM creates a data structure for the soundmap, returning a pointer to the soundmap in which to load the audio data, and an identifier to name it. Soundmaps can be mixed within the UCM, and output to the audio processor.
- Soundmaps can also be looped back by providing the number of the first and last sound groups in the loop, and specifying the number of times which this loop is

to be sent to the audio processor (typically, to fill a given interval, or to repeat one sound a given number of times).

The UCM provides a variety of functions to manage the drawmaps described in Chapter 6, CD-I Discs and Drives, and Chapter 7, Audio and Video on CD-I.

- Within any individual drawmap, the UCM can define two or more discrete or overlapping regions, which can be moved within the drawmap, copied to exchange data between drawmaps, or removed altogether by clipping.
- Regions can be defined down to individual pixels and lines (for example, to effect economical partial-screen updates which address only the most vital information in the image).
- Real-time drawing functions, similar to those in a paint package, can also be effected within defined regions of a drawmap.

The UCM also provides a choice of options for writing text to drawmaps, and coding various text fonts and special characters.

- The UCM offers two approaches to writing text to drawmaps. In its terminal emulation mode, the UCM works like a simple computer terminal with line editing and character attributes, to which familiar text writing and control programs can easily be converted.
- Alternatively, with more programming, text strings can be drawn as to any other bit-mapped objects, to specify the precise starting point and justified length of each string, for more precise control over the text display than the terminal emulator alone affords.
- UCM supports text fonts in data modules which must be loaded into memory. Every character in every font has a discrete code number, bit map and width (although all the characters in any one font may share attributes such as spacing, 'x' height – that is, the basic unit height to which some characters add ascenders and descenders – and the CD-I format in which they are encoded).
- These codes can be interpreted three ways, with the inevitable trade-off between complexity and compression. For complex character sets with a choice of type styles, 16-bit codes support up to 65 536 characters with 16 bits per character; for simpler text displays, 8-bit codes support up to 256 characters. To combine succinct codes for frequently-used characters, and options for special fonts and characters, the 7/15-bit method offers codes from 0 to 127 in eight bits per character, and from 32 768 to 65 535 in 16 bits.

The UCM also oversees the Display Control Program, described in Chapter 6, CD-I Discs and Drives. The only instructions which the UCM specifically supports are those which link the DCP's field and line control tables. Most special effects are controlled indirectly by manipulating DCP commands, but the DCP's activities are merely synchronized with instructions from a control program.

The DCP controls the output of graphics to the video processor, line by line and field by field, but applies its functions under the direction of a program which specifies how various parameters are to be manipulated to create these effects. Fortunately for the programmer, these instructions can be expressed succinctly with the use of libraries and authoring tools.

PROGRAMMING LANGUAGES

Virtually all the first CD-I applications were written in a single computer programming language, C. C was originally developed for use within the UNIX operating system from an earlier language called BCPL, by way of a predecessor called B. It is a high-level language – that is, one which more closely resembles everyday speech than the computer's own low-level code, and which is conceived primarily to address the needs of the application and the user rather than those of the computer itself.

C is popular because it combines the convenience of a high-level language with facility to write at lower levels (for example, to address a specific hardware device in the delivery system). This is particularly apposite in multimedia development, where most instructions are written at a high level of execution within the operating system, but some low-level code is also necessary to send instructions to input and output devices which work on a less sophisticated level. A sample of program script in C is provided at the end of this chapter.

Fourth-generation languages (4GLs)

The alternative to C and other general-purpose computer languages (such as BASIC and Pascal) are the fourth-generation languages (4GLs), which take the familiar syntax of high-level programming a stage further by providing tools for people whose expertise does not include computer programming. Teachers and subject experts, for example, can create their own interactive packages with tools which address their needs rather than those of the computer. 4GLs and other high-level authoring tools typically

employ the familiar features of the WIMP environment (window, icon, mouse, pointer), such as help facilities, pull-down menus and dialogue boxes, which present authors with a set of finite options for every activity which they are likely to pursue.

Conventional computer languages effectively present the author with a blank sheet of paper and a set of rules to govern how it might be filled; 4GLs provide a choice of templates and drawing tools which the author can combine in various ways. They also tend to employ a combination of everyday words, metaphors drawn from real life (e.g. office procedures), with graphics and other visual clues to supplement or enhance text displays. Users see only those commands and options which they need to define the contents and structure of the presentation; the language itself provides, internally, all the extra program code required to translate these instructions from the everyday world into the commands which the operating system and device drivers require.

In fourth-generation languages, too, each discrete element in a presentation becomes a separate object with its own attributes (some of which it may share with other, similar objects). In a multimedia environment, for example, this approach easily distinguishes audio, video and program-related data, and describes each in appropriate terms (in CD-I, for example, by the encoding method and quality level of each). Interactive systems supply the links between objects, and control the internal functions necessary to switch from data of one kind to another.

4GLs emerged alongside expert systems, hypertext and other environments which took a new approach to communications between people and computers. The familiar flowchart adequately describes most conventional computer programs, with their hierarchical branching structure from a common starting point along a given number of paths to a finite choice of conclusions. Intuitive or analytical systems, which employ an element of artificial intelligence or offer many routes between discrete modules of information, require a structure less like a tree than a web, where many diverse paths form a complex pattern of potential journeys and experiences. The two innovations – languages accessible to non-programmers, and structures which aspire to the flexibility of human thought – are complementary, and often used together to allow people with expertise in other areas to apply their knowledge directly to a computer-based system.

PROGRAMMING AND AUTHORING

Authoring properly describes the wide range of activities outlined in Chapter 9, Stages in Production. However, the term is necessarily ambiguous, for authoring now fairly

describes both the work of dedicated computer programmers, and that of specialists from other fields – the one group writing program code in a true computer language, the other using software tools which largely obviate the need for programming skills. In this chapter, authoring assumes the meaning which it largely now enjoys in CBT and IV markets, to describe the activities and products specifically related to the creation of computer code and program-related data.

Authoring for interactive multimedia can be accomplished at any level of computer programming from codes hardly removed from the computer's own binary notation, to hypermedia products which interact with the author at every stage of the production in everyday language and concepts. The range of options now available to interactive programme-makers includes:

- Low-level computer languages, such as 68000 assembly language, which closely resemble the computer's own binary code.
- High-level computer languages, which employ everyday words and concepts.
- Run-time libraries, which supply ready-made codes to effect common functions and routines.
- Run-time engines, which provide a structure which can be re-used several times during the presentation, simply changing the data without altering the way in which they are presented.
- Complete authoring environments, which provide templates and routines from which designers can tailor custom-made presentations.

In practice, many projects employ a combination of tools and proprietary products to increase efficiency, and programming to achieve special effects and features. The first CD-I titles were developed largely through programming, but there are now a number of tools, libraries and authoring products to automate at least the most basic activity. Epic's Clive Shepherd says, 'If there is an easy way of getting the programming done, use it: you are not in business to keep programmers intellectually stimulated by solving problems in Assembler'.[2]

Authoring products are essentially a form of applications software not unlike spreadsheets or database packages. They provide flexible tools with which their users can design a structure to support their own data and presentations. In any one application area, from word processing to multimedia design, virtually everything which users can reasonably expect to do can be reduced to a finite number of options, and proprietary software can be developed to provide programmers with ready-made computer codes to effect these actions. Most such products present the codes required

for any one routine or option as a tidy package which users can implement with a single command.

Such products effectively provide the wheels, so that their users can concentrate on designing appropriate vehicles: ready-made routines obviate the need for every project team to re-invent the wheel for itself. Applications software usually presents users with prompts and options in everyday language rather than the cabalistic abbreviations of computer programming. Many also employ graphical user interfaces and related devices such as icons, pull-down menus, dialogue boxes and instant access to help facilities, to provide all the *aides-memoire* which users may require, entirely within the software itself. The trend, in virtually all areas of applications software, has been away from dedicated programming toward the use of tools which even casual users can employ productively.

The challenge to pioneers is that a few projects have to be completed in any new field to determine what the typical range of creative and functional options may be. Early work in a new environment necessarily tends to be developed from scratch, or with the makeshift application of products developed for other purposes. However, once a few models exist, a gap opens for the suppliers who provide the tools which other developers use to make products for the end market. CD-I in the early nineties, after some years of projects which typically involved as much research as development, is now seeing the development of this important supply line (or, in the popular metaphor of the day, food chain).

CBT and IV authoring products

Over the last few years, CBT and IV designers have tended to work primarily with high-level languages (specifically, BASIC, C and Pascal), or authoring packages (particularly, Microtext and TenCORE, which holds about half the CBT and IV market on its own). Within the CBT and IV markets, authoring systems have tended to fall between two main types.

Prompted systems such as Mentor, SAM and WICAT, present the author with a limited choice of options. These packages are relatively simple to learn and use, but ultimately inflexible. As text-based systems, they also tend to be weak on mathematical functions of the kind demanded by simulations and games, and are not well suited to the development of packages for delivery on a variety of systems or platforms. Thus, many familiar products from computer markets may not gracefully adapt to multimedia systems.

Language-based systems such as Microtext, ProCAL and TenCORE combine many or all of the features of a high-level computer language with routines which facilitate common functions such as answer-judging and interactive branching. With this level of functionality and versatility, these systems usually take some time to learn and use effectively, but reward this effort with the greater versatility of a product designed for use by skilled professionals. Such packages provide some mathematical facilities, but complex simulations and games still generally require additional programming in a computer language. In a feasibility study for the UK Department of Employment, Systems Interactive concluded that 'to convert TenCORE to run on or with the CD-I system [would require] the possible ballpark figure of $1 000 000 and a two-year project with a team of six'.[3]

Some of these products (such as Regency and WICAT) require both software and a dedicated workstation; many others (including TenCORE and SAM) are supplied as software for a variety of computers and workstations. The emergence of new products for CD-I and other multimedia platforms may follow a similar pattern, of both dedicated and platform-independent software. Every CD-I studio must support essential activities such as disc image building and emulation, but specialized applications will also support dedicated tools of many kinds.

The CD-I Enabling Initiative

In 1990, New Media undertook the CD-I Enabling Initiative for the Training Agency, a UK government initiative.[4] This project involved research into the authoring of computer-based training and interactive video programmes, and the design of a range of authoring tools to facilitate the transfer of CBT and IV material to CD-I. Iris Technologies, SPIN UK and Philips Interactive Media Systems (PIMS) assisted with the research, which included appraisals of current trends in hardware and software, and interviews with experienced CBT and IV designers.

The project identified products already in the market for the production of computer-based training, interactive video and CD-ROM applications.

- Conventional authoring systems are based on the principles of computer programming, and require a fairly high level of skills from their users. The demand for these is declining with competition from more user-friendly products, but those which remain address an important niche market for highly-tailored applications.
- High-level authoring packages control every aspect of the production, delivery and management of the interactive presentation. With the emergence of fully-

digital systems, these should also include the capture, creation and manipulation of computer graphics and video images, as well as text, data and audio facilities.

- Increasingly, a single package can be expected to support every stage of activity from creation in the authoring studio to presentation within the delivery system, and to provide management facilities such as student records and system status reports. Obviously, more is demanded in the authoring studio than the delivery system, but appropriate versions of the same software should support the package from first to last.
- Products such as HyperCard are multimedia platforms in their own right, which allow users to create interactive presentations directly on-screen, using the computer alone or external AV sources. They also provide electronic storyboards for work on other platforms. These products can be simple and inflexible or powerful and complex, but all tend to demand powerful computer environments.

At the time of the study, it was observable that the great leap forward in graphics facilities for desktop computers was putting a new range of creative tools into the hands of designers who were not primarily graphic artists.

Paint packages particularly became much more accessible and versatile in the late eighties, and the introduction of software tools for animation, 3D effects, desktop publishing and presentation aids all contributed significantly to the range of creative options. In this, graphics have simply followed the model of applications software from word processing and spreadsheets, in putting efficient tools into the hands of people who have the creative imagination but hitherto lacked the requisite technical skills to execute every stage of production.

The CD-I Enabling Initiative included discussions with CBT and IV designers, to consider their perceptions of the market for authoring products. Most had learned from experience to prefer tested and practical tools, whatever their limitations, to new products which promised much but did not always deliver: several said that they would prefer to work around the limitations of a thoroughly de-bugged system than venture with a package that was versatile but unreliable. (On a related theme, one experienced producer has observed that 'system failures cost much more than just the loss of work: morale, which is critical, soon falls when repeating tasks already successfully completed'.[5]) The designers particularly wanted systems which allowed them to facilitate:

- Prototyping and testing iteratively during the development process.
- Creation, capture and manipulation of graphics.
- The transfer of ideas between designers and programmers.

The interest in graphics, again, reflects both an eagerness to exploit the increased capabilities of personal computers and digital imaging systems, and to address the disproportionate cost of video within a typical IV production budget (where AV may easily account for some 60 per cent of the entire project).

These designers were not eager for frequent software updates, which suggests both that most products work well enough, and that designers have neither the time nor inclination to upgrade their skills and habits without significant incentives. The researchers noted that 'once a particular system becomes established, there is a high resistance to change'. Certainly, most high-level products reward experienced users with higher levels of productivity and creative achievement, which are only attained if the designer continues to use the same system across a number of projects and even platforms. Productivity tools only achieve dramatic results in the hands of trained and experienced users.

PRODUCTIVITY TOOLS FOR CD-I

Many of the pioneers of CD-I programming necessarily developed their own authoring tools to expedite some of the routines identified during those first long, experimental projects. Some of these are now being distributed commercially, while other products are emerging as extensions of popular CBT and IV authoring packages. Developers such as Philips and OptImage, and Capitol Disc Interactive, have also taken the initiative to develop a new range of tools specifically for CD-I.

In practice, many interactive programs ultimately involve a combination of authoring tools and run-time libraries for common functions and routines, and additional material written in a computer language. For the production team, the critical point is to choose the optimum combination of facility and flexibility.

Libraries

Libraries supply a set of ready-made functions which help programmers to execute basic activities without having to write discrete instructions for every task. CD-I libraries provide the codes which all developers need to control the flow of data through the delivery system, and design essential features such as hotspots and screen effects. The CD-RTOS operating system itself employs internal libraries to facilitate many of its activities.

As virtually all the first CD-I applications were written in C, the first libraries were designed to provide off-the-shelf routines which C programmers can enhance with their own code. The combination of library functions for standard procedures, and tailor-made code for special features, expedites the CD-I production process to make optimum use of programmers' skills and time.

The Balboa Runtime Environment, developed by Philips and OptImage, was the first model for CD-I libraries. Balboa is modular, with 16 discrete managers providing a range of functions, and supports multi-tasking on a Sun workstation, Mac II or PC-compatible computer. The Balboa library comprises:

- A Dispatcher to control the execution of functions, a Signal Manager to handle OS-9 signals, and a Play Manager to deliver assets to buffers and control real-time files.
- A Controls Manager to interpret input from the user, together with separate Cursor and Hotspot Managers, plus a Timer to co-ordinate functions with timed intervals.
- Separate Audio, Video and Animation Managers, plus a Video Environment Manager to co-ordinate the use of pointer devices on image displays, and an Effects Manager to handle special effects in graphics, video and animation.
- A Status Manager to record the incidence of errors, debugging, and system status reports, plus managers to support international standards for Non-Volatile RAM files (NVRI Manager) and data in Interchange File Format (IFF Manager).
- Engines to dispatch functions as they are called, and to process signals efficiently, plus a buffer to CD-RTOS.

Capitol Disc Interactive designed another of the first CD-I libraries, again based on C, with tools for system management, debugging and real-time file handling, as well as audio, video and user interface (i.e. cursors, hotspots, controls, text menus and icons).

Libraries provide tools for qualified programmers, who must be prepared to learn how to use them. Balboa, for example, is supported by a four-volume *Programmer's Guide* and *Reference Guide*, and training from Philips. Another level of authoring software puts tools into the hands of non-programmers; Philips' starter system, and the first true CD-I authoring packages, are described below.

Run-time engines

Run-time engines provide a service similar to that of libraries, by creating a framework which can be used any number of times during the same presentation, to deliver

different collections of data in the same way every time. A picture essay, for example, which combines still images with narration, essentially employs the same basic tools no matter what the specific combination of words and pictures may represent. A single run-time engine could supply the code common to all, to which the data specific to each can be applied in turn.

A run-time engine efficiently provides the chassis from which any number of different models can be designed. To work effectively, this is only guaranteed if neither the code nor constants within the engine are changed by any process which employs them. Engines must provide permanent frames which can be decorated in various ways without altering their structure.

Authoring packages

How much any one studio will ultimately invest in hardware and skilled personnel of course depends on many factors, from a long-term commitment to the platform to the ability to finance capital investment. However, CD-I production at any level initially demands some dedicated hardware, if only to provide the experimental platform on which nascent authors can learn their new trade.

Philips' CD-I Starter System is designed specifically to provide a kit with which producers can develop simple CD-I packages, using their own audio-visual material, or generic samples provided with the system. The Starter System is based on a professional-quality CD-I player and the CD-I Navigator™ authoring package, developed by Philips with OptImage. CD-I Navigator comprises:

- A sequence editor, to arrange audio and video material into the real-time files which comprise the bulk of any CD-I presentation.
- A menu editor, to create the interactive branching program, with hotspots to effect users' choices and decisions during the course of the presentation.
- A graphics paint package, which accepts source images from floppy or hard disk, to create and edit images for CD-I encoding, in up to 256 colours, with special effects including 3D modelling, and a choice of four text fonts.
- A clipart disc with samples of graphics in CD-I's CLUT and DYUV graphics formats, and audio at the various CD-I encoding levels, to encourage developers to experiment without having to produce the basic audio-visual resources.

The Starter System allows developers to experiment with sound and pictures in the CD-I environment (which, being purely digital, supports many special effects and

features unfamiliar to those accustomed only to the constraints of analogue video). The Starter System can also be used to create scripts which can be transformed by stages into CD-I discs, with Philips' own facilities.

To complement the Starter System and Navigator, Philips and OptImage developed a proprietary authoring package called CD-I MediaMogul™. Rather than require users to write code or even instructions in everyday language, it provides prompts and *aides-memoire* presented through pull-down menus, dialogue boxes, icons and the other familiar devices of a graphical user interface. CD-I MediaMogul comprises three basic modules:

- Scriptwriter, which employs a timeline to assist in the arrangement of audio and video sequences, and supports effects including animation and partial-screen updates (at five, ten or 15 frames per second). Animation would typically be created with a package dedicated to that function (such as MacroMind Director or Autodesk Animator) and then converted to an interchange file format (IFF) for conversion to CD-I format.
- Editor, which effects the interactive programming through the creation of hotspots and links between various segments in the script, with up to 26 variables for conditional branching between items.
- File Director, which controls the structure of files and directories, and provides housekeeping functions to move, copy and delete files and directories, and preview audio and video files.
- The optional Script to Disc package processes scripts authored in MediaMogul or Navigator for emulation or pre-mastering – the completed presentation can thus be sent directly to Philips for mastering onto a CD-I disc.

Script Systems claim that developers without technical expertise can begin to create CD-I titles with less than three weeks of hands-on experience of their authoring package, Designer's Work Bench. DWB uses the point-and-click routines familiar to users of Apple Macintosh and PC Windows, and automatically translates scripts created at this level into C source code files. With authoring systems of this kind, a picture essay or slide show, with some hundreds of images and a choice of audio tracks, could be produced in a few weeks.

Such software tools put a battery of creative resources in the hands of non-programmers. However, even Philips advise that 'The Starter System is useful for experimenting ... it gives you the means to build interactive sequences, and you don't need any great programming skill. But it's not the means to get into serious CD-I

production.'[6] Authoring packages address one part of the equation, but substantial investment is required to bring all the equipment for CD-I development into the authoring studio.

The CD-I studio

A CD-I disc cannot be pressed until all the data, including both audio-visual elements and program code, are ready and tested. Therefore, authoring must be completed on a hardware platform which can emulate the final delivery system realistically and, during the design of the title, allows authors to move easily between different tasks in the development process.

Authoring stations typically support at least two modes of activity – one to execute tasks such as screen design and scripting of the interactive program, and the other to simulate the appearance and effect of this work on the screen. Testing and emulation are an essential part of any CD-I project, which authoring platforms must support as flexibly as possible – ideally, at a keystroke.

This authoring station may comprise little more than a desktop computer with access to other equipment in a CD-I studio, or may provide all the facilities to develop, test and produce CD-I titles at one workstation. However the equipment is supplied and arranged, the multimedia author must work at a station which can:

- Create computer text and graphics (including captions, sub-titles and animation), usually through the use of a paint package and/or animation software.
- Present all the audio-visual material which has been digitally-encoded elsewhere and, perhaps, capture some of this material directly with grabbers and scanners, and associated image manipulation software.
- Support prototypes of the presentation under development, for analysis and refinement.
- Provide the tools for applications programming, through the use of authoring products, a computer language or a combination of these.
- Facilitate disc image building and emulation to compile the finished program for testing and transfer to a compact disc.

The basic hardware elements of an authoring station comprise:

- A CD-I player which can be connected to a terminal and an emulator (in place of the compact disc drive), ideally with drives for both floppy and hard disks and expanded memory.

- A desktop computer (typically, an IBM or compatible PC or Apple Macintosh) with adjacent hard disk storage of at least 700MB.

Developers who are committed to the CD-I platform also need a variety of resources to capture and edit audio-visual material. These typically include:

- A high-quality 24-bit colour scanner and/or rostrum camera to capture digital images from flat artwork and analogue sources such as video, slides and photos.
- A high-quality 24-bit computer with a large colour monitor (at least 50cm/19 inch), to create and edit original and captured graphics.
- High-quality graphic software to edit and manipulate digitized images, plus a simpler paint package to create new graphics in a digital form.
- At least some basic audio encoding software and editing tools, to supplement the bulk of audio production at a professional facilities house.

Altogether, this typically represents:

- At least one programmer's workstation with storage and processing capacities, and an emulator, capable of testing and prototyping the CD-I disc.
- At least one more workstation for the graphic designer, and perhaps a third specifically for AV or audio designers – or, more practically, two or three workstations equipped so that various members of the production team can work simultaneously without having to wait for hardware or negotiate time-shares.
- A network between individual workstations and a central file server with the largest disk capacity possible. (Some developers prefer to reduce the consequences of system failure by using the server to communicate and transfer resources between workstations, rather than store all data centrally.)
- Such authoring and programming tools as are available and dependable, typically including libraries of ready-made code and run-time engines to facilitate at least the most predictable routines.
- A WORM drive to create write-once read-many check discs in-house, if there is likely to be sufficient demand to justify the cost of the hardware, or if confidentiality agreements preclude the use of an external facility (for example, in a military contract or certain corporate environments).

A modular network can grow with the needs of the organization, and employ the right range of tools for the work at hand and the people who are doing it. The exact hardware configuration which suits any one team or long-term project may only emerge through some degree of trial and error.

Experienced designers and programmers often have informed preferences, and tend to work most productively with hardware and software which they understand and enjoy using. Robert Sorensen of OptImage observes that 'one of the key points to consider on the production side is providing familiar work environments for your employees, or hiring people that are able to use the tools you possess'.[7]

A typical studio in the early nineties might combine a Sun workstation for programming, an IBM-compatible PC for graphics, perhaps an Amiga for video editing, and an Apple Macintosh for preliminary design in HyperCard as well as subsequent audio editing – plus computers for associated tasks such as word processing, financial administration and even project management.

Choosing authoring products

Proprietary authoring systems for the CBT and IV markets have already established criteria for evaluating the next generation of multimedia products. Some basic questions are relevant in the analysis of virtually any authoring tool:

- Is it accessible to general purpose languages (specifically, C), to incorporate tailormade code with generic routines?
- Are run-time functions such as mathematical operations, or answer judging and input analysis, equal to your demands?
- Does it move easily between creation, editing and prototyping?
- Does it support a range of graphics, image capture and animation packages?
- Can it import data from word processing, database or spreadsheet packages?
- Can it collect and export data such as student records or analyses of input?
- How well does it control colour palettes?
- How many text fonts does it provide or support?
- Does it support the products which you already know and use, or plan to use in the immediate future?

Whatever the ultimate choice of products and tools, it is essential that the production team understands both the potential and limitations of the system, and that everyone whose work is affected by the authoring process can estimate how much effort is required to satisfy the design brief.

In choosing products and making decisions, it is also worth remembering the advice of one of the first CD-I developers, Rebecca Newman: 'Consumers don't admire the elegance of your code, but what they get out of your program.'[8]

Licensing fees

Proprietary authoring packages tend not to be sold off the shelf for a flat price but, rather, distributed with a range of licences and fees which reflect the use (and potential profit) which any one developer may expect from the employment and distribution of this particular software.

There may be a single developer's licence, which permits the use of the package at one or more stations in the developer's premises. The developer's licence may also comprise an initial fee, and subsequent site licences for additional copies of the software at several stations, in the same site or at different sites within a single organization. When the programme itself requires a version of the authoring software to run on delivery systems, there is often a subsequent fee for that additional use of the product. This run-time licence is usually a flat fee, but could be a form of royalty (perhaps, a percentage on every package sold, or every recorded incidence of use).

Run-time licences are usually less for professional or in-house packages than for consumer products: a published training package or custom-made marketing programme could require a less expensive licence than a game for the commercial market. Licensing fees, like copyright, will be features of a commercial environment to which developers from corporate backgrounds must pay special attention, in the new world of electronic publishing for consumer markets.

Notes

1 John Garcia, Novalogic, speaking at the Second Multimedia Conference on Interactive CD, London, 29–30 May 1991, sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.

2 Clive Shepherd, Epic Interactive Media Company, speaking at the Second Multimedia Conference on Interactive CD, London, 29–30 May 1991, sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.

3 Systems Interactive, Compact Disc Interactive Feasibility Study, UK Department of Employment, Sheffield, undated c. spring 1990.

4 New Media Productions, *Authoring Tools for CD-I: A Report of the Training Agency*, January 1990 (revised, June 1990).

5 John Gray, Capitol Disc Interactive, speaking at Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.

6 Declan Dickens, Philips Interactive Media Systems, *Audio Visual*, September 1990.

7 Robert Sorensen, OptImage Interactive Services Company, speaking at the Second Multimedia Conference on Interactive CD, London, 18–19 June 1991; sponsored by Philips, Sony, Matsushita, PolyGram and Maxwell Communications.

8 Rebecca Newman, developer of *Cartoon Jukebox*, speaking at the Sixth International Conference and Exposition on Multimedia and CD-ROM, San José, 18-20 March 1991, sponsored by Microsoft.

A SAMPLE PROGRAM

This sample, by New Media's Technical Director, Dr. Graham Sharpless, illustrates a typical segment of program script written in C for use in a CD-I presentation. It displays a control panel on the screen, which users can employ by clicking the appropriate buttons. The control bar (Fig. 11.1) comprises 16 buttons arranged in two rows.

INIT	AUDIO 1	VIDEO	PLAY >	STEP >	FAST >	SCAN >	INDEX
FADE	AUDIO 2	STOP	PLAY <	STEP <	FAST<	SCAN <	BORDER

Figure 11.1: Sample Control Bar

The script comprises the following nodes and commands.

Node #	Commands
#0	Initialize system, define variables, set grid size
#1	Define buttons for control panel
#10	Initialize player
#12	Turn video picture on
#13	Turn video off
#16	Turn Audio channel 1 on
#17	Turn Audio channel 1 off
#18	Turn Audio channel 2 on
#19	Turn Audio channel 2 off
#20	Play forward
#22	Stop playing
#24	Step forward one frame
#26	Index on
#27	Index off
#30	Step reverse
#32	Play reverse
#34	Scan forward
#36	Scan reverse
#40	Hide menu bar (copies bar to sprite)
#45	Fast forward
#47	Fast reverse
#60	Displays border colours
#80	Exit program

The listing is given below.

Video player control shell

```
#0 Start
*
MODE PAL
* declare vars
VAR X1
VAR X2
VAR Y1
VAR Y2
VAR BORDER
VAR BTN
* set grid and disable timeout
GRID 8 10
TIMEOUT 0 0
* set colours
COLOUR F 7
COLOUR B 7
COLOUR S 1
COLOUR T 8
COLOUR H 15
* set variables for border
SET Y1 164
SET Y2 176
SET BORDER 0
* initialize video player
MIC "INIT"
*
* draw buttons on screen
*
SPRITE INIT 4
#1 *** define buttons ***
* clear screen
PAINT 0
```

```
CLEAR 0
COLOUR T 8
BUTTON E 1 0 8 10 "INIT" init
BUTTON E 2 1 8 16 "AUDIO 1" audio 1
BUTTON E 3 2 8 12 "VIDEO" video
BUTTON E 4 3 8 20 "PLAY >" play fwd
BUTTON E 5 4 8 24 "STEP >" step fwd
BUTTON E 6 5 8 45 "FAST >" fast fwd
BUTTON E 7 6 8 34 "SCAN >" scan fwd
BUTTON E 0 7 8 26 "INDEX" index
BUTTON E 8 0 9 80 "EXIT" EXIT
BUTTON E 9 1 9 18 "AUDIO 2" audio 2
BUTTON E 10 2 9 22 "STOP" stop
BUTTON E 11 3 9 32 "PLAY <" play back
BUTTON E 12 4 9 30 "STEP <" step back
BUTTON E 13 5 9 47 "FAST <" fast rev
BUTTON E 14 6 9 36 "SCAN <" scan rev
BUTTON E 15 7 9 60 "BORDER" border colour
BIGBUTTON B 16 0 0 10 10 40 to hide menu bar
*
LINK
*
#10 **** initialize player ****
MIC "INIT"
LINK
*
#12 **** video on ****
MIC "VIDEO ON"
COLOUR T 14
HIGHLIGHT Text 3
BUTTON B 3 2 8 13
LINK
*
#13 **** video off ****
MIC "VIDEO OFF"
COLOUR T 8
```

```
HIGHLIGHT Text 3
BUTTON B 3 2 8 12
LINK
*
#16 **** audio 1 on ****
MIC "AUDIO ON /A1"
COLOUR T 14
HIGHLIGHT T 2
BUTTON B 2 1 8 17    audio 1
LINK
*
#17 **** audio 1 off ****
MIC "AUDIO OFF /A1"
COLOUR T 8
HIGHLIGHT T 2
BUTTON B 2 1 8 16    audio 1
LINK
*
#18 **** audio 2 on  ****
MIC "AUDIO ON /A2"
COLOUR T 14
HIGHLIGHT T 9
BUTTON B 9 1 9 19    audio 2
LINK
*
#19 **** audio 2 off ****
MIC "AUDIO OFF /A2"
COLOUR T 8
HIGHLIGHT T 9
BUTTON B 9 1 9 18    audio 2
LINK
*
#20 **** play ****
MIC "PLAY"
COLOUR T 14
HIGHLIGHT T BTN
```

```
SET BTN 4
HIGHLIGHT T 4
LINK
*
#22 **** still ****
MIC "STILL"
COLOUR T 8
HIGHLIGHT T BTN
LINK
*#24 **** step fwd ****
MIC "STEP"
COLOUR T 8
HIGHLIGHT T BTN
LINK
*
#26 **** index on ****
MIC "INDEX ON"
COLOUR T 8
HIGHLIGHT T BTN
COLOUR T 14
HIGHLIGHT T 0
BUTTON B 0 7 8 27
LINK
*
#27 **** index off ****
MIC "INDEX OFF"
COLOUR T 8
HIGHLIGHT T BTN
COLOUR T 14
HIGHLIGHT T 0
BUTTON B 0 7 8 26
LINK
*
*
#30 **** step rev ****
MIC "STEP /R"
```

```
COLOUR T 8
HIGHLIGHT T BTN
LINK
*
#32 **** rev play ****
MIC "PLAY /R"
COLOUR T 8
HIGHLIGHT T BTN 14 8
SET BTN 11
COLOUR T 14
HIGHLIGHT T 11
LINK
*
#34 **** scan fwd ****
MIC "PLAY /SC"
COLOUR T 8
HIGHLIGHT T BTN
COLOUR T 14
SET BTN 7
HIGHLIGHT T 7
LINK
*
#36 **** scan rev ****
MIC "PLAY /SC /R"
COLOUR T 8
HIGHLIGHT T BTN
COLOUR T 14
SET BTN 14
HIGHLIGHT T 14
LINK
*#40 **** hide menu bar ****
* get menu bar as sprite
SPRITE COPY 0 0 160 639 199
COLOUR F 0
BLOCK 0 160 639 199
WAIT
```

```
SPRITE PASTE 0 0 160
LINK
*
#45
MIC "PLAY /F"
COLOUR T 8
HIGHLIGHT T BTN
SET BTN 6
COLOUR T 14
HIGHLIGHT T 6
LINK
*
#47
MIC "PLAY /F /R"
COLOUR T 8
HIGHLIGHT T BTN
COLOUR T 14
SET BTN 13
HIGHLIGHT T 13
LINK
*
#60 **** border colour ****
CLEAR 0
SET BORDER 0
SET X1 0
SET X2 79REPEAT 8
COLOUR F BORDER
BLOCK X1 0 X2 19
ADD X1 80
ADD X2 80
ADD BORDER 1
ENDREP
SET X1 0
SET X2 79
REPEAT 8
COLOUR F BORDER
```

```
BLOCK X1 20 X2 39
ADD X1 80
ADD X2 80
ADD BORDER 1
ENDREP
WAIT
COLOUR F 0
BLOCK 0 0 639 80
LINK
*
#80
*END
*
#END
```

12

Case history

This chapter describes one of the first CD-I titles privately undertaken, with government support, to investigate the potential for publication in professional markets.

Japanese for Business Travellers was made for the first generation of professional-quality CD-I players, before any version of the consumer player had been released. Thus, like most early CD-I titles, it necessarily involved research and development within what was essentially a commercial undertaking. This case history considers both the typical stages in development of any CD-I title, and some of the lessons learned during the first years of producing programmes for interactive compact disc.

BACKGROUND

The project which eventually became *Japanese for Business Travellers* was developed in response to a call for proposals for the development of technology in training, in 1989. This was issued by the Training Agency, one of the most prominent initiatives within the UK Department of Employment.

The project brought together two companies with special expertise – New Media, who had been producing interactive multimedia programmes on a variety of platforms since 1984, and Vektor, who specialize in the development of interactive material for language learning.

New Media had produced one of the first European language training packages on interactive videodisc, for Eurocentres in 1986, and had already designed one of the world's first CD-I discs, the *Grolier Multimedia Encyclopedia*. Vektor publish a series of language study packages called *The European Connection*. The four primary objectives of the project were:

- To develop learning materials which could make training more widely available.
- To assess the suitability of CD-I as a medium for distance learning materials (and language learning in particular).
- To assess CD-I as a medium for teaching Japanese through distance learning.
- To stimulate the development of other language learning materials in CD-I.

The project effectively became the first in the world to produce generic or off-the-shelf training material for professional markets in the CD-I format. Its finished work is a fully functioning prototype for language courses on CD-I.

PROJECT TEAM

Japanese for Business Travellers was a project supported by a Training Agency grant, which brought together two independent companies with complementary specialisms, and required the detailed advice of a subject expert. It therefore had a more elaborate structure than most interactive multimedia projects.

This included a steering group drawn from the Learning Technology Unit of the Training Agency, the Japan Business Services of the University of Sheffield and, as project managers responsible to the Training Agency, Transcend Technology. The Japanese consultant to the project was provided by the School of Oriental and African Studies of the University of London.

New Media's team comprised a project manager, technical director, software engineer, AV producer, production assistant and graphic designer. Vektor's team brought in a creative director and another software engineer.

Administration and financial management of course involved the secretarial and accounts staff of the principal organizations – professionals whose skills provide an essential complement to the creative and technical teams, no matter what the subject and scope of the project.

TIMETABLE

Japanese for Business Travellers began in August 1989, and was completed by December 1990 – some 17 months of work at a time when quick projects were being turned around in 6 weeks and a typical interactive video training programme might take 8 to 12 weeks. The project was divided into five principal stages, which reflected the

essential production work of any interactive multimedia programme, and the additional research and development required by this initiative.

ADAPTATION STUDY

A six-month adaptation study was undertaken by New Media and Vektor between August 1989 and January 1990. The study considered how the transition to CD-I would affect Vektor's methodology for the production of language learning material on interactive videodisc, by identifying:

- Immediate examples of enhancements and constraints which the transition from IV to CD-I would occasion.
- Unexplored features which required practical investigation during the development phase.
- Areas where new elements must be developed for the instructional and visual design, and functionality, of the interactive programme.

The study began by defining the principles of Vektor's established methodology for interactive distance learning:

- A needs-led, modular approach to the content and structure of information.
- Extensive use of visual, non-verbal communication techniques.
- Extensive use of interactive features, and quick retrieval and response times, to give users full control of the programme.
- Practical use of audio-visual material (specifically, moving footage) to present typical dialogues in realistic contexts.
- Software design and execution which particularly supports rapid response times, considerable volumes of text, responsive use of audio-visual segments, and powerful but friendly user interface.

It was clear from this analysis that the software would have to provide replay of virtually any element on the disc and, specifically, instant access in any direction between the last, current and next utterance in any dialogue or example of speech. A high-quality graphical user interface would be required to support easy and efficient interface with users who could not be expected to have any relevant experience of interactive distance learning materials.

Advantages and constraints

CD-I offers low-cost players which answer one of the main objections to technology-based training from organizations conscious of the capital expense of delivery systems. CD-I also offers better audio facilities than LaserDisc, with a range of quality levels for different parts of the programme – a considerable advantage in language learning. Finally, the potential for attractive and dynamic screen design and interface was greater in CD-I, with its single disc and versatile structure, than anything Vektor could achieve with interactive video on LaserDisc.

There would also be serious constraints in the transition from the full-motion, full-screen video inherent to LaserDisc, to the first generation of CD-I systems. Response times may be slower in CD-I than IV, and the difference between the consumer and professional biases of the two products meant that the computer keyboard, so common in IV delivery systems, would not immediately be a standard feature of the CD-I unit. The responses to these issues are discussed below.

Audio-visual standards

The transition from IV to CD-I effectively represented a trade-off between enhancements and constraints in the technical differences between the two platforms.

- Audio quality obviously had to reproduce the subtle inflections of a foreign language clearly enough for students to recognize and study short phrases very closely – a feature CD-I supports very well.
- Equally, visual material had to convey both the nuances of expression and body language, and precise details such as lip movements in images which would bear close scrutiny by the student – a feature which IV supports effortlessly.
- It was important, too, that users should find the audio-visual material attractive and engaging, and that both the physical settings and professional delivery of scenes and dialogues should appear authentic and natural. Whatever the platform, acting, shooting and editing all must encourage a natural, unforced style of speech, expression and body language.
- At the same time, everyone from the scriptwriter to the AV editors had to remember that any individual action or utterance should be immediately accessible for replay or closer examination by the student. The individual components of any one dialogue must represent a natural conversation, but still work effectively in isolation as examples of specific learning points.

Vektor's IV presentations make extensive use of the high-quality video which is LaserDisc's salient feature. When the adaptation study began, in August 1989, full-motion, full-screen video on CD-I had only been seen on a videotape of a technical prototype. However, moving pictures could be achieved at less than full-motion, in windows within the full-screen.

- It seemed possible that two sizes of windows, with images of different quality, would support close-ups of lip-synched speech from 'talking heads', and larger scenes of body language and dialogues. Video quality would be less than that of broadcast television, but might be acceptable to training audiences accustomed to VHS videotape.
- After some experimentation, it was clear that, even at 30 per cent of the full screen size, the larger window still required too much data to support moving pictures of sufficient visual quality. It was decided to restrict moving footage to a window 16 per cent of the full screen size, with images renewing at the rate of 15 frames per second (as opposed to PAL/SECAM's 25, and NTSC's 30 fps).

This decision had the positive consequence of ensuring that all video windows would be of exactly the same size (and could thus appear in exactly the same place). The team eventually decided to maintain the same window format for all still and moving pictures and graphics in the lessons. This enhanced the consistency of both the visual design and the user interface, and ensured that all visual material would be displayed within the screen's safe area.

Functional differences

CD-I has slower 'seek times' than LaserDisc – that is, the time required to move the laser beam within the player from the data it has been reading, to the point at which new data will begin, and for the disc within the player to spin round to the position at which the reading head can begin to pick up the new information. In Vektor's methodology, any one utterance in an audio-visual sequence may last up to three seconds (but no longer), and users can replay this, or jump to the next or last utterance in a sequence, instantly. CD-I ultimately supported seek times of just over half-a-second, which was equal to users' actual expectations at this level.

When this project began, in the autumn of 1989, the single-box 1.0 model player and CD-RTOS 1.0 operating system were new to the professional market. First experiments with seek times were conducted on the .99 three-box professional system, but

even then the CD-I player's performance compared favourably with that of the IV system.

To replay or jump between adjacent utterances, users simply point the CD-I player's remote control device at one of three arrows on the screen (representing the current, last and next three-second sound bite) and click the button on the controller. On the .99 system with a 68000 processor, about half a second elapsed between the click of the button and the presentation of the selected sequence. The 1.0 drive and faster 68070 processor subsequently improved on this.

One of the principal challenges to both designers and programmers lay in the transition between two radically different approaches to screen interface and input. Vektor's interactive video courses used the IV system's computer keyboard as the main input device; the hand-held CD-I remote-control unit is a radically different tool with relatively limited functionality. At the same time, the potential for effecting interaction through graphical user interfaces (that is, icons and objects on the screen) is considerably greater in CD-I than IV, so many essential elements of Vektor's methodology had to be radically re-assessed to effect a positive transition from one platform to the other.

INSTRUCTIONAL DESIGN AND SOFTWARE SPECIFICATION

The instructional design and software specification were completed in February 1990. The instructional design defined:

- The curriculum for the course, which provides an introduction to modern conversational Japanese for business travellers. The package addresses social skills rather than the specific vocabulary and conventions of business meetings, and provides examples of words, phrases and conventions used in greetings, telephone calls, social visits, the traditional inn, restaurant, bank, travel desk and department store. The package was designed, at least initially, for a British audience of English speakers.
- The methodology, which comprises an overview, a tutorial, eight dialogues (corresponding to the topics described above) and a self-administered test. Each dialogue is scripted and acted to create the impression of authentic conversations, which users can watch from start to finish as an unpaused dialogue; however, in a second version of each scene, users can also pause to replay individual utterances, and to study and compare details such as vocabulary, syntax and pronunciation.

- The graphical user interface, which is designed to maintain consistent conventions throughout the course (in this case, using the CD-I controller's keypad and joystick to effect choices and responses from users).

The software specification addressed:

- The low-level routines, which execute procedures or functions which are frequently employed during the course of the application. These typically include initializing the CD-I environment, controlling the cursor, defining hotspots, blitting blocks of pixels to and from images, playing moving video and handling still images (i.e. loading images from the disc, allocating them storage in DRAM and displaying them on the screen).
- Complementary high-level software, which resides in one CD-RTOS process, and calls on low-level routines from the C library functions provided by Microware, and the User Communications Manager (UCM) within CD-RTOS to effect specific parts of the presentation.

It was initially agreed that New Media, with greater experience of the CD-I environment, would be responsible for the low-level software and Vektor, with deeper understanding of the language learning course itself, would undertake the high-level programming. New Media prepared the software specification, which described every routine in the application by defining:

- A mnemonic and meaningful name for each routine.
- A description of the activity which the routine should effect.
- A list of the parameters (i.e. information) to be passed to the routine.
- A list of return values (i.e. instructions) which would return the presentation from a routine to the main program.

From this, a subsequent specification addressed the low-level software specifically in terms of:

- Names, descriptions, parameters and return values, on the model of the main specification.
- The C calling interface to transfer control from the main program to the routine.
- Possible errors which any one routine might encounter.
- An example of the correct use of each routine.

Previous experience had demonstrated how easily misunderstandings and errors can arise from inconsistencies alone – particularly in communication between the design

and programming teams, and the production company and its external suppliers. From the outset of this project, New Media specified precisely how still images were to be prepared, drawn, grabbed, named and stored. This included parameters for image size, brightness levels for individual pixels, CLUT locations, colours for transparent areas, and the definition of safe areas on the screen. These technical and administrative procedures – which included practicable conventions for the mnemonic and meaningful naming of image files – were published internally for distribution to everyone on the production team.

New Media prepared and delivered training to introduce Vektor's team to CD-I and the CD-RTOS operating system. In the event, New Media ultimately designed both the low-level and high-level software, although Vektor was involved with program design toward the end of the project.

AUDIO-VISUAL PRODUCTION

All the audio-visual material in the programme was created specifically for this package – no archival footage or images were employed. AV production began in January 1990 and was completed by March.

The script was written by the Japanese language consultant, who worked closely with both Vektor and New Media. Vektor has specific responsibility for the pedagogical elements of the dialogues, and New Media for dramatic quality.

The visual material comprised still photos, graphics, and moving video, all of which had to be produced to address the technical demands of the CD-I platform.

- This required particular attention to the lighting, which was designed to create warm colours without extremes of contrast.
- As it had been agreed to contain all the visual content of the lessons within a 'video box' 16 per cent of the full screen size, all still and moving images and graphics had to be designed and assessed for clarity within that area.

Some basic decisions about the dramatic and visual aspects of the dialogues facilitated a short and efficient shoot:

- The three actors were auditioned with particular attention to the naturalism of their performance, and the precise articulation of their Japanese speech. The language consultant assisted during the auditions to ensure that all three had both the fluency and orthodox delivery required in a language teaching programme.

- A single lattice-work set provided an unobtrusive backdrop to all the video sequences. This lent a Japanese air to the scene without suggesting specific locations, which had advantages of economy and versatility, at the cost of the interest, variety and contextual information which other sets might have provided.

The video sequences were filmed in London in March 1990.

- Each dialogue was shot twice – once as mid-shots for unpaused dialogues, which users watch from start to finish, and again in a series of big close-ups for paused dialogues, which can be interrupted and studied in detail.
- The video was shot, edited and mastered on Betacam SP. This videotape format records a component video signal, which preserves more of the chroma and luminance values of the image than a conventional composite video signal. This is another technique specifically chosen to enhance the visual display on CD-I.
- Editing and mastering both paid close attention to Philips' technical specifications to ensure that the audio-visual material maintained the optimum signal levels, tape formats and video lead-in requirements for the CD-I platform.
- The video material was finally transferred to broadcast-quality U-matic videotape and digitally encoded at Philips Research Laboratory (PRL) in Dorking, UK, to ensure that individual images were correctly cropped and positioned.
- Voice-overs were recorded separately, and the edited voice-over tracks were transferred to half-inch audio tape, to be digitally encoded by PRL.

The still photos were originally shot in Japan, by a photographer commissioned by one of New Media's colleagues in Tokyo. There was an immediate penalty for relinquishing direct control here, for the images were of poor quality, and although some were re-shot in London, the overall quality of the stills was disappointing.

Graphics

In *Japanese for Business Travellers*, a database of signs illustrates graphical images typically associated with street signage, buildings, information services and travel facilities. This image database was created by New Media in London, working from the photographs taken in Japan. These were grabbed and exported to a graphics paintbox, where they were coloured and amended as necessary, as digitally-encoded computer graphics in the CLUT format.

New Media designed the graphics to create a unique visual atmosphere within the programme, and to meet the technical constraints of the CD-I screen display. As well

as the video box which displayed the still and moving images, there was a standard control panel which had to appear consistently in a location complementary to the video box, but also within the screen's safe area. The graphics screens were created in TIPS software and then digitally encoded as CD-I files.

The icons in the graphical user interface were purely visual. Although it was eventually felt that a combination of keywords and visual *aides-memoire* would have been best for the icons – e.g. a forward arrow and the word 'Play' rather than the arrow alone – in the event, text of the appropriate size for the icons would have been too small to read on low-resolution TV sets.

The on-line help facility, always accessible from a simple screen, partially addresses this shortcoming by providing brief descriptions of the functions of each visual icon, should users forget or confuse their meanings. The icons were modified after the first trials of the disc with typical users, to make them more clear and functional.

AUTHORING

When the project began, both New Media and Vektor thoroughly understood the interactive video authoring process, and New Media had the further distinction of practical experience in CD-I, something known to very few companies in 1989. In this project, authoring specifically described the development of the software which controlled the interactive presentation.

The technical team began work during the last quarter of 1989, familiarizing themselves initially with Vektor's methodology for IV, and the content and structure of the Japanese language programme.

Here, it was New Media's established methodology which provided the model for the new project. Experience had validated the basic principle of multi-tasking – that is, treating every component of the presentation individually, and bringing together the disparate elements of sound and pictures, graphics and video only in the final presentation.

The New Media team now wanted to improve the functional performance of the system by reducing the time spent seeking and opening individual files, and the time required to load still images or seek data in real-time sequences such as video scenes and picture essays.

The software team also wanted to improve the audio-visual quality of the interactive presentation by:

- Improving the presentation of moving video sequences.
- Ensuring that all visual material is displayed consistently within the screen's safe area.

They had other objectives, to facilitate the authoring of this package, and provide tools and routines that could be used again in future projects. These included:

- Identifying common jobs that could be facilitated by employing or creating standard, re-usable library routines.
- Establishing a standard layout for all instructions in the Field Control Table (FCT).
- Creating a generic software product to play 'picture essays' with still images, text and sound.

Previous experience also suggested some specific examples of good practice which were implemented successfully in this project, such as:

- Allowing several attempts to open or read a file during delivery.
- Checking for error return from every UCM library call.
- Using 'csd_getdev' to get the names of various devices, rather than assuming their names (e.g. /cd, /ap, /vid).
- Testing the entire application with all the input devices that users might employ – in this case, both the CD-I controller and a mouse – to ensure that every interaction works with every device.
- Testing the entire application on both PAL/SECAM and NTSC monitors to ensure that every screen is adequately displayed.
- Reducing the likelihood of load errors, and the incidence of memory fragmentation, by ensuring that sub-processes – however often they may be forked up, executed and killed off during the course of the presentation – are only loaded once. (Once loaded, their link count is incremented so that they stay in memory even after being killed off. The link count is decremented back to 0 at the end of the application, and the sub-processes released from memory.)

Creating computer graphics

The detailed work which went into the software specification paid off during the authoring phase, which was expedited by the clear guidelines laid down for the management of graphics and still photographic images.

All the images were ultimately encoded in CD-I formats, and a data sheet was devised to provide a central, standard record which defined the file name and machine

from which source data came, the target file name, image coding method, size, CLUT locations, and the names of the team members who prepared the image, and who received it for integration into the program. These data sheets were effective, but the New Media team felt that better documentation systems could yet be devised, and have continued to refine these systems through subsequent projects. The software specification also determined that:

- Moving video and still images coded in DYUV would be displayed uniformly on Plane B.
- Elements of the graphical user interface such as menus, icons and objects would be coded in CLUT and stored on Plane A with chroma key transparency.

This allows the text and graphics from Plane A – which are used to select, respond and control elements of the programme – to appear in front of photographic images from Plane B, which deliver the visual content of the lessons. The consistent use of the two image planes combines a familiar aspect of the IV delivery system with CD-I's greater functionality. The CD-I authoring environment allowed the graphic designer to preview work in progress on a typical delivery system, and make adjustments or implement successful ideas immediately.

Implementing low-level routines

In addition to the new 1.0 model player, the other critical piece of authoring hardware for this project was the emulator. After a review of the products then available, New Media chose STEPS PAS/3 from Script Systems. The emulator was used to edit, compile, assemble and link all the source code in the program.

STEPS PAS/3 is an IBM AT-compatible personal computer with 20mHz 80386 processor. A Motorola 68020 processor board plugged into the PC's motherboard runs the OS-9 operating system on which CD-RTOS is based, so the emulator can function as an industry-standard MS-DOS or OS-9 computer: each operating system has its own hard disk, but files can be transferred from one environment to the other. The emulator provides a much more powerful environment for authoring than the relatively low-performance 68000 processor in the CD-I drive (which is, after all, a modestly-priced product for the consumer market, and not a professional authoring platform). However, the technical team needed some time, and the experience of trial and error, to master the complex scripting languages employed by STEPS' real-time file builder and CD-I image builder.

New Media wrote the low-level routines mainly in C, employing 68000 assembler for a few functions in which speed was particularly important, and reusing some of the code developed during earlier projects. Differences between the two generations of the player and CD-RTOS soon became apparent when routines developed for .99 versions were applied to the 1.0 drive and operating system. Some of the code which had been written around bugs in the .99 version was no longer needed, but some new challenges had to be addressed through creative programming until the new bugs could be tracked down and eliminated.

All bugs and technical problems were relayed back to Philips in Eindhoven, who frequently compared notes with New Media's technical team to determine whether faults were caused by programming and other errors, or true bugs. Some problems had already been encountered, others were new even to Philips. The platform itself was still so new, and experience so limited, that teething problems were inevitable: at least by sharing information about obstacles and solutions, the companies already on the learning curve gained practical experience, and added some new tricks to their repertoires.

Paused language learning

The high-level code for paused language learning was addressed first, being seminal to Vektor's methodology. This portion of the course combined CLUT images in the foreground (Plane A) with photographic DYUV images in windows on Plane B, the moving video sequences (shot and edited by New Media, and digitally encoded by PRL), as well as PRL's decoding routines for moving video, and both high-level and low-level software routines.

This activity identified both bugs within the new hardware and software, and lessons in production strategy:

- Problems with the moving video sequences revealed that New Media's videotape machine was incompatible with PRL's, a discrepancy which engendered many errors in the digitally-encoded video data.
- PRL had encoded the width and height of each frame into the actual frame data, rather than treating these as data parameters within the moving video decode routine. An error in either of these values could crash the system.
- The player could hang, or lock up, if any one real-time sequence (such as a three-second video clip) were replayed more than once. The source of this bug was never discovered.

- A delay of more than 20 seconds between video clips could also cause the system to lock up if the student so much as paused to make a note. Much experimentation eventually resolved this by using the 'lseek', rather than 'ss_seek', function to send the laser reading head to the start of the next segment.

In Paused Language Learning, every dialogue is divided into a series of individual utterances lasting no more than three seconds each. Once the video segments were digitally encoded, the time codes from the U-matic master tape had to be translated into CD-I sector numbers. This could only be effected through trial and error, and proved a time-consuming and often frustrating task.

Database of signs

The next phase of authoring addressed the database of signs. The coding here was relatively straightforward, but there were a few surprises in the visual material.

- The DYUV image data was stored in an odd byte boundary, which caused the CD-I system to transpose the luminance and chrominance levels for each sign. The radical difference in colours between the source material and the DYUV images on the screen caused considerable confusion until the source of the problem was identified and addressed.
- All the images had to be re-grabbed from the source slides to rectify a problem with framing.
- The signs had been shot against such a variety of background colours that the whole screen seemed to jump when the display switched from one extreme to another. A uniform background was applied to each image; closer quality control during the photo shoot should obviate such problems in the future.
- Each sign was to be accompanied by a short audio recording of its Japanese name. In practice, some signs had no complementary sound bite, while other audio recordings could not be matched with any corresponding image.
- Discrepancies in administrative procedures also caused problems: computer files which did not adhere to naming conventions could be mislaid or lost, and newly-recorded material was not always fully annotated.

This section of the programme provides four icons to represent the street, information, buildings and travel, the categories in which the signs are arranged. The original designs for these proved too small and complex to convey any meaning on the screen. New images were designed, and encoded separately for display together on the screen,

but the differences between adjacent pixels in these DYUV-encoded icons caused unpleasant visual effects. Finally, the four new signs were encoded as a single graphic, and programmed to access four separate sections of the signs' database.

The balance of the programming activity comprised the high-level software which provided the specific teaching, testing and introductory facilities described below.

Unpaused language learning

The third phase of the programming addressed those versions of the eight dialogues that students can watch from start to finish, with sub-titles, as short dramatic sequences, the unpaused language learning.

Much of the code written for the paused sections was re-used here, but a number of new problems arose with the addition of moving video and subtitles from text files. Amongst other things, the video was often jerky while subtitle text was being erased and written, which suggested that odd frames were being dropped during this activity. Even at speed of 15 fps in a 16 per cent window, the CD-I player was being pushed to the limit to display moving pictures and supply subtitles at the same time. These problems were resolved by optimizing the decode-and-display loop for the moving video sequences, and dealing intelligently with the odd dropping of a video frame.

Another challenge arose in structuring the code so that users could pause and resume at any point, with full access to the features of the application, even though the processor was only part-way through the moving video sequence. This was resolved with a special call-back function, which is invoked whenever the moving footage pauses. This duplicated code from other parts of the disc, but a small degree of redundancy was justified by the functionality of the solution.

A final surprise was waiting when the application was tested in the CD-I player's Multi-Media Controller (MMC), with its 1MB of RAM, without the addition 1MB in the Expansion Module. Fully a quarter of the frames were dropped, and the lip-synch particularly was unacceptable for a language learning programme. Many discussions with Philips Research Laboratories and Philips Interactive Media Systems eventually revealed that accesses to RAM in the MMC are 33 per cent slower than those in the Expansion Module, because the RAM in the MMC is shared between the main 68070 processor and the video hardware, and the processor-to-memory bandwidth is reduced accordingly. RAM in the Expansion Module, which is free of this constraint, was just equal to the demands of moving footage; RAM in the MMC was not.

Self-test on signs

The next phase of the programming was relatively easier than those which had gone before, but also involved some unanticipated work.

After studying the database of signs, students can undertake a self-test which presents them with a multiple-choice quiz to match the meaning of any one sign from a choice of five options. This requires a random number generator to ensure that the four incorrect options are not always the same, and that the correct answer does not always appear in the same place.

The random number generator comprises two functions – 'return pseudo-random number' and 'see the pseudo-random number generator' – which are usually provided by the operating system, or within the C library of functions. However, there was no reference to either in the CD-RTOS documentation, nor in Microware's manual for their library of C functions, so New Media had to implement both from scratch. This was time-consuming, but the routines are at least now a part of New Media's own library of low-level functions.

Self-test on language learning

Students can also test themselves on the material studied in the main part of the course (that is, through the paused and unpaused dialogues). This self-test was the most complex and difficult phase of the whole program – and the watershed from which the project rolled smoothly to completion. Vektor helped to prepare data, design and create the programming for this section.

The sheer complexity of the task demanded a radical approach. Rather than write reams of code required to calculate all the data here, the team shifted the emphasis from code writing to data gathering. Data was prepared and computed to describe every aspect of the functionality in the self-test module, and simply presented to the code as a parameter. The preparation of the data was laborious, but the final application is both robust and easily amended.

Overview and tutorial

The first sections which the student encounters were the last to be programmed. The overview was straightforward, but the tutorial posed new challenges.

The tutorial effectively comprises a demonstration of all the main features in the course – paused and unpaused language learning, the database of signs, and the two

self-administered tests (for signs and language learning) – with a voice-over to explain each one. This represents ideal material for a picture essay which combines still images with narration.

In programming terms, a picture essay is usually held in a single real-time file, with all the material arranged sequentially, since the essay is linear rather than interactive. The software which controls the real-time file responds to triggers which dictate when to load and display still images, when to load, decode and display motion video and where to move the cursor on the screen to simulate typical interactions.

It was soon apparent that such a structure is impractical within the CD-I environment. To extract the relevant data from the original real-time files, build a new real-time file, and play all these data, would require a great deal of storage space and processing power, duplication of code and, probably, software tools which simply did not yet exist.

The radical solution lay in creating a set of pointer device messages which effectively simulated a live demonstration. Special code was written to direct the cursor to the appropriate icons and objects, and activate these as though someone in front of the screen were using the hand-held controller. The final presentation looks like a conventional tutorial, but uses the actual content of the programme itself, rather than a discrete demonstration module.

The tutorial was created as a separate process, running in parallel with the main process and the cursor process. When the tutorial is run, it is simply the tutorial process itself which feeds the cursor process with point-and-click messages identical to those normally sent from the controller. The cursor process accepts this input and passes it on to the main process as though an actual user were in control.

It only remained to add the narration at the appropriate points in the demonstration, which was a straightforward piece of programming. The final presentation is essentially a picture essay, but is much easier to implement and more versatile in structure than the conventional model.

Tidying up

The last phase of the programming devoted perhaps 5 per cent of the total effort to tidying up some 20 loose ends. Many of these simply addressed bugs in the system, others refined elements of the visual and structural design.

- An intermittent fault in the database of signs sometimes silenced the first second of the audio narration which supplies the Japanese pronunciation. The cause of

this was elusive, so a second's worth of silence was simply added to every sound bite in this group, to protect them all from the random fault. When the bug does not occur, the second's silence is not distracting, and the silences could be removed altogether when the bug is fixed.

- Still images originally stored in Mode 2, Form 1 – that is, with full error detection and correction codes – could not be loaded in real-time, so the error protection was traded for speed, and still images were subsequently stored in Mode 2, Form 2. Loading stills in real-time is essential, and New Media felt that having discs pressed by a top-quality manufacturer (in this case, Nimbus) significantly reduces the need for protection at this level.
- A new feature was added at this stage: if the first-time user does not select an option within 15 seconds of starting the course, the system automatically presents the tutorial, on the assumption that the novice does not yet fully understand how to use the package.

Preliminary field testing also identified small problems with the design of certain icons and objects, the legibility of some numerical characters, and the functionality of the control panel, which were easily addressed at this stage.

EVALUATION

The University of Sheffield and Lancashire College, Chorley, assisted in the evaluation of the course in 1990, by making the interactive programme available to mature students from a variety of backgrounds. Vektor designed and managed the evaluation, but New Media compiled the final report.

At the University of Sheffield, the system was set up in a conference room, and users were given a brief introduction to the programme and the remote control device, before being left on their own to work with the package as long as they liked.

At Lancashire College, 35 participants in an international course for teachers and trainers used the package, and offered constructive comments about it. A second group of eight, from a course for teachers of modern languages, worked with the programme for up to four hours apiece and completed a detailed questionnaire. The package was also demonstrated to staff of an engineering company which had come to the College for a cultural briefing on Japanese language and customs.

Detailed evaluation

Another 15 people from a variety of backgrounds also completed the questionnaire and provided the evaluators with detailed information about themselves and their impressions of the course.

The majority were in or near their thirties, but the group ranged in age from 23 to 65. Three were managers, three were engineers, six were lecturers or teachers (two, of languages); an accountant, a designer and a housewife made up the balance. All spoke English well and all but one had some knowledge of another language, several were fluent in at least two European languages, and two were accomplished polyglots. Most felt that some knowledge of Japanese would help them in their work, although a few were simply curious about the language or the interactive multimedia system: all were in some way motivated to use the programme.

Some of the 15 had already studied Japanese. Some spent only a few hours with the package, others used it often. By the end of the study, six of the group could communicate as tourists, and five had sufficient skills to participate in a business meeting or speak on behalf of a group. The production team were gratified to discover that, although the language consultant thought that users would have difficulty learning to recognize Japanese signs, 90 per cent were correctly identified when the users undertook a printed test at the end of the exercise.

The questionnaires completed by this group of 15 indicated that mature and motivated students at least are not overly concerned with the aesthetic differences between multimedia systems and broadcast television, so long as the content of the programme interests them and the interactive features are seen to enhance the learning experience. Technical rather than pedagogical issues occasioned most of this group's comments and suggestions.

Fully 13 of the 15 thought the quality of the still images was good or very good, and only one thought the moving video sequences were poor – ten thought they were good, and two even rated them very good. Most were satisfied with the size of the images, and 12 of the group thought the screen layout and colour scheme was good or very good. The principal concern was the neutral background – the latticed screen which appeared in all the video sequences. It was felt that more realistic settings would have enhanced the authenticity of the programme, and allowed some of the dialogues to flow more freely over real sets and props, as ordinary conversations do.

Navigation through the interactive programme seemed to divide the group about equally between those who found the system easy or very easy to use, and those who never found it more than acceptable. This was reflected in responses to the thumbstick

and the control panel on the screen, as well as general issues such as 'learning to use the programme' and 'understanding what to do'. The design team accepted that some refinements would improve both the structure and appearance of the user interface. Yet 12 of the 15 had no problem navigating within the programme, and only five had difficulty 'knowing where you are'. All found the Course Map useful or very useful, and most appreciated the Introduction.

However, it was clear that students would welcome more support for first-time users, and some form of manual or workbook for all students. The classic designer's dilemma also emerged, for some users were frustrated that they could not begin work immediately, but had to learn about the interactive system itself first; equally, while none disputed the value of multimedia, many would also have appreciated that familiar medium, the workbook, to record and reinforce what they learned from the programme, and to take away for future reference.

It was interesting that both the absolute beginners and the accomplished linguists often had the same responses to the content. Most were well satisfied with the structure of the package – paused and unpaused dialogues, instant replay facilities, Japanese and English subtitles, the choice of audio or video alone, the use of big close-ups, and the two self-administered tests. Over half found the study of facial expressions and body language useful, but there was less interest in the study of lip movements. A couple of users speculated on a fully interactive system which would hear and correct their pronunciation; the design team agreed that some form of voice capture and replay would be a desirable enhancement, although this presents the current generation of CD-I systems with the same hardware problems as IV, if a set of disparate peripheral hardware is added to the standard delivery system.

At the same time, many of the students felt that the dialogues were spoken too quickly, and some found it difficult to distinguish individual words or even voices. The design team accepted this, and agreed that users should be able to hold subtitles on the screen as long as they wished. They also agreed that, in a programme for people unfamiliar with Japanese and perhaps even with language studies, the phonetic representation should be as simple as possible, and very clearly explained. Even with the depth of experience within companies such as Vektor and New Media, it is still only too easy for those close to the programme to become too familiar with it: only the spontaneous reactions of real users can give designers the feedback they need to make appropriate decisions.

Inevitably, though, some users will take issue with fundamental decisions which inform the entire structure of the programme. In this instance, the design team felt that

users would have to accept, for example, that Japanese is generally recognized as a difficult language to learn, and there is a point beyond which no instruction can make it simpler. They also felt that users accustomed to other teaching methods would have to accept that literal translations are neither pedagogically desirable, nor technically feasible, given the profound differences between Japanese and English. The designers also stood by their decision to reflect the dominant role which men still take in Japanese society, despite one student's criticism that the programme was male orientated. Research at this level may reveal flaws in the structure or social values of the programme; sometimes, too, it identifies decisions which might be more clearly explained or more sensitively addressed, but which are fundamentally sound.

PROMOTION

New Media began to include descriptions of *Japanese for Business Travellers* in their media pack and promotional material in 1990. By the end of December 1990, when the project was officially completed, *Japanese for Business Travellers* had been demonstrated at some 15 conferences, seminars and exhibitions in the UK, France, Italy, the Netherlands, the United States and Australia, where New Media were exhibiting or one of the Directors of the company was speaking.

In October 1990, *Japanese for Business Travellers* won the Innovation Award of the British Interactive Media Association (BIMA) at their annual dinner during TIME '90, the year's largest European multimedia show.

IMPLEMENTATION

It was expected that *Japanese for Business Travellers* would be completed to coincide with the launch of CD-I as a commercial product. In the event, nearly a year elapsed between the completion of this prototype and the release of the first CD-I players on the American consumer market, in October 1991. The lack of players in homes or professional environments, therefore, hindered the subsequent development of the project in 1991.

However, it is expected that further funding will be available – mostly likely, from industry (which has a growing need for Japanese language training), particularly when full-screen, full-motion video becomes a standard feature on CD-I. A greater range of

video facilities would considerably enhance the prototype's versatility and potential. Nonetheless, even as a fully functioning prototype, *Japanese for Business Travellers* has received critical support from potential users (in professional and educational environments) and from the language training community at large. As multimedia systems become more common in homes, schools and workplaces, programmes like this one presage a new generation of information, education and entertainment.

Appendix 1

Video and computers

This appendix explains a number of basic concepts from the worlds of broadcast television, video and computing – the established markets from which a new generation of multimedia products evolved.

To understand how multimedia systems work, and appreciate their advantages and constraints, designers and developers should understand the key words and concepts behind:

- Bits and bytes, discs and disks, programmes and programs
- Analogue and digital
- Frames, fields and lines
- Compression and decompression
- The international video standards, NTSC, PAL and SECAM

The specific technical issues associated with data storage on discs – including vinyl, LaserDisc and compact disc formats – are addressed in Appendix 2. Readers with experience of interactive video, audio-visual production or computing will probably be familiar with some or all of these topics, but may yet find it useful to skim these two appendices to appreciate how these several strands are brought together in multimedia systems.

HOW TO SPELL MULTIMEDIA

Those unfamiliar with the vocabulary of the computing market may particularly be confused by words which look similar but for a letter or two. The difference between bits and bytes, discs and disks, programmes and programs is important, for the

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variations represent critical differences in meaning. This is not an affectation: discreet and discrete, effect and affect, imminent and immanent also carry important distinctions in a few letters. The key concepts in this market are:

Bits and bytes

Most of us are so accustomed to the decimal system that it is hard to grasp any other way of counting. But the choice of 10 is arbitrary, based probably on the fingers of the human hands rather than any specific model of numerical data. Numbers do not inherently come in batches of ten, and equally logical systems of analysis and computation have been based on longer and shorter patterns. In the decimal system, we have unique characters for numbers from zero to nine; after that, the characters must be combined, in a rigidly sequential fashion which is universally recognized: after '9' comes '10', after '19' comes '20', after '99' comes '100' and so forth.

This is a more complex system than we, who are so accustomed to it, may appreciate, and for systems which communicate through simple signals such as electronic pulses, decimal notation is demanding. The singular advantage of many modern communications systems is that they reduce all data to a binary code which has not ten, but only two, components. These can be expressed as simply as zero and one, on and off, high or low, present or absent, with a given number of signals comprising one unit of data, and an agreed signal, such as a pause of pre-determined length, marking the start and finish of each piece of coded information.

The principle is similar to that of Morse code, which uses a combination of long and short signals to reduce the alphabet to a binary form. Barcodes, which appear on many consumer products, similarly employ a pattern of wide and thin lines and spaces.

- The smallest piece of information in a digital code – a single pulse of electricity in a signal, a single magnetized particle on a videotape, a single pit on the surface of a LaserDisc – is a bit.
- A set of bits large enough to constitute a unique code is a byte (a contraction of 'by eight', since a byte usually contains eight bits).

In Morse code, from one to five bits are sufficient to create enough unique codes to cover both letters and numbers. A string of eight bits allows computer-based systems to communicate a great volume of information in a way which is both extremely quick and easy for a processor to code, send, receive and decode, and which allows very little possibility of error.

However, bytes are small, and bits are infinitesimal; it takes thousands of them to comprise even brief messages. So, for practical purposes, volumes in computer storage media are usually measured in kilobytes ('KB' or thousands, literally 1024, or 2^{10}) or megabytes ('MB' or millions), although the inexorable increase in storage demands and capacity extends to gigabytes (billions) and terabytes (trillions). Thus, a single computer graphic might require storage space of 210KB (where all the signals needed to describe the image in binary code comprise 215 040 bytes), while the ultimate data storage capacity of a compact disc is 650MB.

The numbers used to describe computer graphics, in terms of the maximum number of colours which can be supported, also refer to binary calculation: 4-bit formats offer only 16 colours (2x2x2x2 or 2^4), while 8-bits support 256 colours (2^8), and so on up to the 24-bit formats which provide the '16 million' colours (actually, 16 777 216) to which so much product literature refers.

Discs and disks

The distinction between discs and disks – different types of round, thin and flat data storage media – is not always strictly observed. It is of course artificial – the same distinction between spellings of sceptical and skeptical does not signify a difference in meaning – and some people see no need to distinguish by spelling between the various media.

However, as more and different kinds of consumables are now reaching ever-wider markets, and media of different types are often combined in the same delivery system, it is useful to distinguish between:

- Magnetic computer disks, which contain data, text, graphics and sound specifically for a computer-based system. These include the large volume 'hard disk' which is often built into the computer itself, and the portable diskettes which are also called 'floppies'. ('Floppy' is a bit confusing, since 13cm/5.25 inch disks are flexible, but 9cm/3.5 inch disks are rigid, and both are protected by casing which is neither round nor floppy, but the word is at least unique in a technology with much ambivalent terminology.)
- A range of capacitive and optical discs – including vinyl records and LaserDiscs – which can contain a variety of digital computer data and analogue audio-visual signals. These discs vary in diameter from 30cm/12 inch LPs and LaserDisc formats to 12cm/4.75 inch CDs and mini-CDs.

A typical interactive video system, for example, combines text, graphics and computer data from a magnetic floppy disk with sound and pictures from a reflective optical LaserDisc.

Programs and programmes

The distinction between program and programme is not always observed, and is growing less clear with the development of multimedia systems, however:

- Computer programs are usually a means to an end, whether applications such as spreadsheets or word processing packages (which have no intrinsic value or meaning, but which can be used to produce a great deal of diverse information) or simply sets of commands to other machines (including other computers) which control functions and processes.
- Audio-visual or multimedia programmes contain a variety of information which is generally useful on its own, although it may (like a computer applications program) also be manipulated in different ways.

The distinction is useful within interactive and multimedia packages which necessarily contain applications software or commands to the delivery system, as well as audio-visual content. A CD-I programme, for example, employs control programs to direct the flow of data from the disc through the CD-I player to the television and/or hi-fi.

ANALOGUE AND DIGITAL

Analogue and digital are spelled very differently, but the distinction between them is not always clear to those who do not work regularly with computers or audio-visual media. Yet the difference between 'old' and 'new' in communications technology often means the difference between 'analogue' and 'digital'.

- Most of the audio-visual products which surround us now – radio, television, video and audio tape, records – are analogue, based on technology developed directly from processes in the natural world. In analogue systems, the subtly fluctuating signals in any one piece of data are represented by electrical voltage or a magnetic field in a continuous flow of uninterrupted information.

- All computer-based systems – and most compact discs – are digital, employing a radically different approach to information storage which is entirely artificial, and also extremely efficient. In digital systems, individual signals are taken at regular intervals as samples of the continuous analogue stream, and expressed as numerical points in a finite scale – in a typical range of 256 colours, for example, black is represented by 0, at one end of the scale, and white by 255, at the other.

Analogue data can be digitized – that is, converted to a digital form – and aspects of this conversion process are discussed in detail elsewhere. The advantages of digital information processing are explained in more detail in the discussions which follow, and elsewhere in this book.

Analogue

We receive information from the natural world in a steady stream of constantly varying signals: temperature, humidity and atmospheric pressure constantly rise and fall, if only by minute increments. These fluctuations are usually too subtle for our senses to measure accurately without assistance: thus, we use a thermometer to mark the temperature, or a barometer to record the atmospheric pressure.

To give meaning to this information, we impose analogous values on the scales by which we measure it: for example, 212°F or 100°C are the values analogous to the temperature at which water boils at standard atmospheric pressure of 760mm of mercury. The mercury in a thermometer provides a constantly varying analogue signal – the units in the Celsius and Fahrenheit scales are measures of that datum. All three scales are arbitrary, but at least they give us a standard by which to sample, analyse and exchange essential information.

Sample is the magic word, for the information continues to flow and fluctuate even as we are measuring it. To record the subtlest differences requires extremely sensitive equipment – faculties more sensitive than those of the human mind and body. To process, store and communicate a constantly varying signal also requires a great deal of space and power.

However, in practice, our senses are easily satisfied with a series of closely graduated samples which, when transmitted rapidly in sequence, provide enough information to keep our perceptions constantly engaged. Accurate samples taken regularly at frequent intervals provide as much information as we would consciously perceive through direct personal experience.

One of the first successful sampling systems was of course film, which typically records 24 separate still images for every second's worth of moving footage. We receive sound and pictures from the real world as an unbroken stream of constantly varying information; yet a movie, with a steady flow of 'samples', provides enough data for our eyes, ears and minds to perceive information which appears realistic to us.

Digital

Sampling is the essence of digital technology, which does not attempt to capture every subtle fluctuation in a signal, but simply takes representative extracts of uniform size at regular intervals which, collectively, reproduce the data accurately enough for the purposes at hand.

The more frequent the samples, the more accurate the reproduction. A digital recording of high quality takes many samples, at frequent intervals; a recording of lower quality takes fewer samples, further apart. The discretion with which these signals are processed (both in recording and replay) is the other critical factor: the more minutely graduated are the levels which can be identified, the more accurate and subtle the reconstructed pattern will be. In an audio recording, frequent samples at finely-shaded levels of sound are necessary to reproduce a classical symphony in its glory, but a plain voice-over could be satisfactorily preserved much more simply. (This is the essence of the different 'levels' of sound and picture quality available in the various multimedia systems.)

This is a wholly artificial approach to recording, storing and transmitting data from the natural world, but it has some striking advantages. Obviously, less data are needed for simple recordings than complex ones, so where storage capacity and processing power are limited, resources can be deployed strategically.

Most importantly, digital data can be radically simplified to the level of binary notation – that code in which all information is reduced to a choice of two signals. This is ideal for machines with processing power, such as computers or microprocessors, which need only register a curt message such as 'pulse/no pulse', or 'magnetic/not magnetic' to create the pattern of information, which is then separately decoded. The basic data are extremely simple and uniform, and can be processed at great speed: this would be a cumbersome way for people to communicate, but for electronic systems, it is highly efficient.

Moreover, with a system so simple, digital data are also extremely stable, and can be transmitted over long distances virtually without distortion. All signals are

weakened and distorted by electrical 'noise' every time they pass through an electronic circuit – which AV signals do every time they are recorded, copied, edited or broadcast. Complex analogue signals suffer from every degradation – digital signals are more resilient. It is also easier to 'clean' digital recordings by identifying extraneous data (such as noise) and removing those fragments from the signal. This is why digital CDs have a higher signal-to-noise ratio – more pure sound and less superfluous 'hiss' – than conventional LPs or tapes. The fine network of magnetic particles on a videotape, or the undulating grooves on a vinyl record, employ analogue recording techniques, and are subject to the technical constraints of increased noise and deterioration.

Broadcast radio and television, and the many audio-visual products developed in their wake, initially employed analogue recording and processing techniques modelled on phenomena of the natural world which they exploited (such as electricity and microwaves), and analogue broadcasting systems are still the most efficient for the large volume of data which television in particular demands. Digital systems are increasingly used to facilitate editing, and copying of tapes without loss of quality, but still require too much bandwidth to support practical broadcast technology. Also, with the enormous number of conventional TVs, VCRs, and broadcast facilities now installed worldwide, television and video systems are likely to employ analogue broadcast technology for some time to come.

Videodisc systems, such as LaserDisc, were developed as products for an established market, and actually use digital encoded techniques to store analogue data. Thus, a videodisc (although it processes data digitally), reconstructs it for use on an analogue television monitor, and is as tied to conventional video technology as a videotape. One of the sterling benefits of a purely-digital approach in CD-I is freedom from those restraints, in a standard which was conceived to be universal.

VIDEO BASICS: FRAMES, FIELDS AND LINES

However the signal is stored and processed, the composition of the video image still informs much of the designer's work with conventional sources and systems.

Frames

Video, like film, creates the illusion of moving pictures by presenting a carefully-graduated series of still images so quickly that the human mind and eye cannot

distinguish between them. We need about one-fifteenth a second to register the presence of a single image, and we absorb very little information in so brief an interval. Anything with less than 50 repetitions per second can leave us conscious of 'flicker', but moving pictures which travel past our eyes at anything approaching this rate can create in our minds the illusion of continuous motion.

- Film is now standardized at a rate of 24 frames per second (although very old movies often move at disconcertingly different speeds).
- Video is divided between three international standards – NTSC, PAL and SECAM – described below. What matters here is that NTSC, the standard employed in North America and Japan, moves at a rate of 30 frames per second, and PAL and SECAM, the European standards, move at 25 frames per second – and both divide a single frame into two complementary fields, so that the flow of information is effectively doubled.

Thus, a video recording requires at least 25 separate pieces of complex information every second. This is, by computing standards, a great deal of information indeed, not only to store, but also to process.

In computing terms, a single frame of video, when converted to digital data as a conventional RGB computer graphic, requires storage space of at least 600KB, and a transfer rate of around 15MB per second. (That is, if a single video frame typically comprises 614 400 bytes of information, video transmitted at a rate 25 frames a second would need to send some 15 million bytes of data through the system every second, to present full-colour moving pictures with sound). Altogether, with essential control programs and related data, a compact disc with 650MB of storage space could hold a large encyclopedia in text alone, but no more than 48 seconds' worth of video.

To retrieve text from a CD-ROM disc and display it on screen, the processor within the computer needs to transfer data from the disc through the system at a rate of about 150KB per second – that's about a thousand times slower than the 15MB which a conventional video system demands. The ways in which multimedia systems address this challenge are discussed briefly below and in more detail in the body of this book.

Fields

A single *frame* of video has another distinguishing feature: it is divided into two complementary *fields*. These are transmitted separately, and interlaced on the screen to form a composite picture. Data transfer rates are a problem even for conventional

television and video systems, so dividing the data in this way helps to keep a manageable flow of information in motion.

For one thing, when 25 or 30 frames are divided into 50 or 60 fields, and the video is moving at speed, there is so much information speeding through the system that it is possible to add or remove single fields without detracting noticeably from the quality or coherence of the overall presentation.

Removing fields at regular intervals reduces both the storage space and processing capacity required by a single piece of moving footage. This is one of the techniques used to compress video signals for more economical storage and processing in multimedia systems. Adding or subtracting fields also helps to convert moving footage from one frame rate to another.

For example, film runs at 24 frames per second, NTSC video at 30: to supply the missing six frames, the conversion process called 'three-two pulldown' creates two video fields for every frame of film, and then duplicates one field in every second frame to create 12 new fields. This brings the final running speed up to 30 frames (or 60 fields) per second. (Conversely, material run without conversion simply moves faster or slower at the different rate: a 60-minute video shot at 30 frames per second would shave a full 10 minutes off its running time at 25 frames per second, while an hour of film shot at 24 frames per second could more acceptably be broadcast in 57 minutes and 36 seconds at 25 frames per second.)

So long as the pictures keep moving, these effects are rarely noticeable. However, it is essential to have two matched fields to display a stable image motionless on the screen. This is important in recording a still frame (which is designed to be motionless), or selecting a freeze frame (which is created when the system simply stops on one image in a sequence of moving footage). It sometimes happens that a system picks up two fields from adjacent but different frames: interlacing two fields which do not quite match produces the jitter or flicker which you can sometimes see in a still or freeze frame. If by chance the two fields sit at the very point where the tape was edited, they can even come from different scenes.

Where 'field dominance' is a problem (as in interactive video production for LaserDiscs), it is important to ensure in the editing suite that every video sequence starts and stops uniformly on the same field. In the UK, the even field is usually 'dominant', but some video systems prefer the odd field. (And in the US, the British even and odd fields are paradoxically called first and second.) The best answer here is to work with video editors and facilities where interactive disc-based systems are understood, and to seek advice from experienced programme-makers if you are unsure yourself.

These are the familiar problems of interlacing: the emergence of high-resolution images is creating another. 'Intermeshing' was first patented in 1929, to support the earliest broadcast television, and has not adapted gracefully to the sharper images and more versatile technology used today. For one thing, broadcast TV requires a greater bandwidth, or transmission space, than desktop video. Television, too, is designed to be seen from a distance, but many modern information systems require their users to sit directly in front of the screen. Yet the same video footage may appear in a television broadcast, a non-broadcast video and a disc-based presentation: the technical demands of each are different, but the source material is the same.

The challenge to developers is to adapt a variety of source material to the demands of each medium. Fully-digital audio-visual platforms rise above these problems with coherent images which are not divided into complementary fields, and therefore do not require interlacing. Non-interlaced images are both more stable, and more easily manipulated for the range of special effects which multimedia systems provide.

Lines

The division of frames into fields, and thence into lines, is a legacy of broadcast television. To handle the steady stream of data in a broadcast signal, television systems divide the picture into a number of parallel 'scan lines', and transmit these very rapidly across the screen. The first pass in a scan typically picks up the even-numbered lines, the second picks up the odd-numbered ones, and the two sets are all laid down across the screen so quickly, and renewed so often, that we are left with the impression of a smoothly flowing motion picture. (Hence the importance of field dominance, to ensure that the pattern is always the same.)

- Scan rates from 405 to 819 were used by various broadcast systems before the present standards were set.
- NTSC now uses 525 lines in every screen, while PAL and SECAM use 625. PAL and SECAM, accordingly, produce a sharper picture than NTSC.
- A new generation of high definition television (HDTV) proposes to double the current standards. The Japanese MUSE HDTV standard uses 1125 lines per screen, while the European HD-MAC system uses 1250.

While a higher rate of scan lines per screen undoubtedly produces more detailed pictures, the technical demands of information on this scale are well beyond the capacities of the current generation of computers and multimedia devices.

This is where one of the essential differences between multimedia and conventional audio-visual production clearly emerges. In television or video, no matter what the nature and source of the visual material – whether it begins as a century-old daguerreotype or the last word in computer animation – it must eventually be transferred to some form of videotape, where it occupies proportionately the same space as material from any other source. Ten seconds of video eats up the same number of fields and frames whether it is displaying a moving sequence of subtle animation, or a still frame.

In multimedia systems, images of different kinds require different levels of storage space and processing power. Ten seconds of moving video demands a great deal more than a still frame which is held motionless on the screen for ten seconds. Ten seconds of simple animation uses less space and power than ten seconds of full-screen, full-motion video. Thus, every creative decision is influenced by critical technical factors such as those explained here.

COMPRESSION AND DECOMPRESSION

There are, of course, alternatives to conventional video technology: it is possible to record a video frame with less than 600KB of data, and to process it at a transfer rate of less than 15MB per second. This is done by compressing the volume of data required to store and process the image, and decompressing this signal when the time comes to display the fully restored image on the screen.

The various compression – and decompression – techniques used by CD-I and other multimedia systems are discussed in detail elsewhere. The principles common to them all are best illustrated, quite literally, by the garish modern cartoons which fill up hours of children's television.

The simple outlines, crude colours and limited animation of today's popular cartoons contrast with the finer quality of animated cinema films. But animation is an expensive business, and television demands cost-efficiency. Animators achieve this in much the same way as multimedia producers.

- Motion can often be limited to small areas of the screen – the lips and eyes of the character who is speaking, for example – while everything in the background remains static, or changes less often.
- Using a limited number of colours, and applying these in fairly large blocks, reduces the sheer volume of colour-coding in any one image.

- When the difference between one frame and the next is relatively small – a patch of motion, a slight change in colour – it is possible to record not all the data in every field or frame, but only that the start of a sequence, and the changes which occur subsequently. (Or, commonly, a reference frame at regular intervals, and then only the information which varies from one reference point to another.)

These techniques can be used with some subtlety in multimedia systems, to effect considerable savings in storage space and processing power. The essence of all compression systems are mathematical algorithms, which establish patterns to identify essential information, store it compactly, and then reconstruct the full image again by interpreting the recorded data. Once the algorithm is established, compression and decompression are merely routines; the catch is that different algorithms are appropriate for various kinds of information, and indeed for different multimedia platforms.

The important thing for a designer to observe is that single photographic image, for example, contains more detail and greater variations in colour than a chart created by a computer graphics package. Again, setting the relative value of one medium over another, when the calculation is technical as well as creative, is one of the unique challenges facing multimedia designers.

INTERNATIONAL STANDARDS: NTSC, PAL AND SECAM

To appreciate another of the benefits of CD-I and other multimedia platforms, it is necessary to understand that conventional TV and video systems are tied to a range of technical standards which vary from country to country. These developed differently for historical reasons, before video was a product and when there was little interchange between national television networks; now, they are a nuisance to the free exchange of hardware and programmes across national borders, but it will be a long time before all the world's televisions and monitors are replaced by a single international standard.

The acronyms ascribed to the three principal combinations actually describe only their approaches to colour coding, but provide handy labels nonetheless:

- NTSC (National Television Standards Committee), the standard employed in the US, Canada, Mexico, Japan and their various dependents.
- PAL (Phase Alternate Line), the standard developed in Germany and used in Britain, most of western Europe, and much of Australasia, South America and Africa.

- SECAM (Séquential couleur à mémoire), a variation of PAL developed in France and adopted by the USSR and its erstwhile dependents, principally those in eastern Europe.

Professional TV and video facilities have equipment to convert material between the various standards, and keen consumers can buy multi-standard video players for the home. However, there are still barriers between the standards, not the least of which is that neither hardware nor software are necessarily exchangeable over national borders – so do not send a videotape between New York and Paris without checking that the receiving end has a compatible player and monitor.

CD-I cuts through this Gordian knot by employing a single standard for all hardware and software, which is compatible with all three television standards and the universal RGB (red-green-blue) computer monitor as well. The only difference between the various international markets for CD-I hardware is the shape of the plug, and software is universally exchangeable – at least technically (the cultural differences which might be revealed in the contents are the stuff of another book altogether).

However, the televisions to which most consumers will connect their CD-I player are still tied to one of the three basic standards, and all of the archival material which programme-makers may wish to use is necessarily produced in NTSC, PAL, SECAM (or even on some form of film stock, which has yet another set of technical parameters). The technical constraints of designing for NTSC, PAL and SECAM displays are addressed in the main body of this book, for it will be some time yet before the multimedia market is entirely free of these irritating acronyms. The key points to note about the three standards are:

- The 'size' of the screen, which is based on the bandwidth, or broadcast 'space' available to the signal: NTSC employs 525 lines per screen, while PAL and SECAM use 625.
- The 'speed' of the transmission: to obviate electrical interference, the internal signals which synchronize the broadcast are linked to the national power grid. Thus, NTSC (based on a power frequency of 60Hz) runs at a rate of 60 fields, or 30 frames, per second; and PAL and SECAM (based on 50Hz), both run at a rate of 50 fields, or 25 frames, per second.
- The method of coding colour: all three systems (like the human eye) compose and broadcast luminance (brightness) separately from chrominance (hue and saturation), so the actual black-and-white picture is separate from the colour code which enhances it. NTSC is the simplest system (and, for its limitations, is also known

as Never Twice the Same Colour), and is wholly incompatible with PAL and SECAM. PAL is essentially an enhancement of NTSC, with a more subtle and stable image. SECAM uses different colour coding methods, but is basically compatible with PAL. Thus, material exchanged between PAL and SECAM loses the colour signal, but can handle both audio and a black-and-white video image.

Eventually, a new generation of wholly-digital television and video technology may sweep away all such distinctions as NTSC, PAL and SECAM. Alternatively, something as yet unheard-of may yet displace television and video as we know it. In the meantime, the world is littered with millions upon millions of analogue television and video systems, broadcast and studio equipment. The technological revolution has a way to go yet.

VIDEO ON THE PC

The computer graphics in an ordinary arcade game of 1991 render the best efforts of 1981 positively primitive by comparison – only think back to *Pacman* or *Space Invaders*. For people who have worked with computers for ten years or more, it can be astonishing to remember to what lengths creative minds went – hardly more than a decade ago – to force the simplest designs from software packages which required a computer programmer's skills to turn out graphics which might have been hand-drawn by a talented child.

Well, it *should* be astonishing to remember how recently that was, but people who work with computers positively expect progress at this rate, and people who do not work with computers hardly think about their limitations at all. It is easy to imagine that it is a short leap from arcade games to desktop video. But we still have to remember that video, particularly, is a demanding medium which comes from a much different technical environment than computer graphics.

Even film and video went through many changes, over the better part of a century, to reach the standards internationally recognized today. Technical considerations included both the size of the recorded image (for example, 35mm film or half-inch videotape), and the rate at which still pictures were projected to create the illusion of movement. Video is now standardized at a rate of 25 or 30 frames a second, but what concerns us here is the simple fact that anything which typically requires at least 15 separate, complex items of information *every second* must use a great deal of storage space and processing power.

A whole technology has developed to support the production and dissemination of film and video, and it isn't computing. Computers may be used extensively in the film and video industry, particularly to facilitate editing and broadcasting functions, but to use a computer in lieu of a recording medium such as video tape or disc, demands more than most computers can easily deliver.

Personal computers were not designed to handle large quantities of audio-visual information – few, in fact, were originally expected to handle graphics or sound at all. The rapid development over the last 10 years or so, first of computer graphics, and latterly of audio processing facilities, has transformed our perception of what a computer can do: no longer just a number-cruncher or word processing machine, but a multimedia device capable of processing information of many kinds.

Science fiction makes much of computers which have the intellectual resources (and even the social skills) of a well-developed human mind, but practical experience has taught most people that real computers, in the workplace, are eccentric machines whose relentless pursuit of linear logic sometimes puts them dramatically at odds with their human operators.

With the inception of multimedia systems, our perceptions are shifting again, to some middle ground between science fiction and job frustration, as computers become more powerful and versatile. Technical developments have increased the storage and processing capacity of desktop PC networks to levels hardly achieved by some old mainframes. But equally, a radical shift in attitudes within some parts of the computer industry itself has initiated a revolution in the design of both software and accessories, to make machines more serviceable to people whose skills and interests lie outside the hard science of computer programming, in the myriad disciplines to which computers can be applied.

This 'transparency' in the technology is all to the good, if it helps more people make better use of common technology. But, at the same time, we are perhaps moving too easily toward the uncritical view of the omnipotence, and even omniscience, attributed to a package of boards in a box by humorists and futurists. How often do we hear 'computer error' blamed for what could only be the human error of a computer operator?

In fact, computers are relatively straightforward machines with clearly-defined technical limitations. You usually get what you pay for, and it requires a good deal of storage space and processing power to produce complex graphics or moving pictures in any form on a computer alone. The various methods of compressing (and decompressing) video images are not merely an economy, but a necessity, if computers

are to support audio-visual presentations of any complexity with resources to separate storage media such as videodiscs.

In evaluating any multimedia system, it is important to remember that computers alone were not designed to handle full-motion, full-screen, full-colour video. That desktop video systems can now offer a form of this demanding technology is a tribute to the technical skills of hardware and software designers alike. However, where true moving video forms an important part of the presentation, it is still only sensible to look to an audio-visual medium to store and process that large volume of complex data.

Appendix 2

Data storage on disc

This appendix explains how discs of various kinds – including vinyl records and optical discs – are used for data storage. Some technical terms used here – such as analogue and digital data processing, and the standards which govern conventional video production – are explained in Appendix 1.

DATA STORAGE ON DISCS

There is a certain irony in the recent fall from favour of that archetype of data storage discs, the vinyl record. Records seem to have gone, almost literally, the way of dinosaurs, as an example often cited as technology which didn't work quite well enough. Yet both records and dinosaurs were uniquely successful for a relatively long time, and both have evolved in a variety of useful ways. Many living things owe their distant origins to dinosaurs, and all forms of data storage on disc reflect the principles first tested in that home entertainment market. If the human race survives for 160 million years, and CD is still a recognizable product in the year 2070, both will be doing very well indeed.

In the meantime, it is easy to see how discs work, by observing a vinyl record. (It may also be useful to get a grasp of the language of new technology by reading a comparative description of something as familiar as an LP).

On a typical long-playing record, all the data on the disc – even the silences between separate items – are stored contiguously, so that the recording runs from start to finish without pause. The recording itself appears as one continuous groove, arranged in a tight spiral on the surface of the disc. It begins at the outer edge, and finishes near the centre. There is always a narrow lip around the outside of the disc (a 'lead in' area),

and a blank space around the hole in the centre (a 'lead out' area). The size of the latter varies according to the length of the spiral groove: the longer the recording (or 'programme area'), the smaller the space left at the end. Most records are double-sided, so there are usually two separate recordings on a single disc. Domestic hi-fi systems only read one side at a time, and users must turn the record over manually, by opening the turn-table, removing the disc, turning it over, and returning it to the machine.

If all this sounds too obvious for words, it is a testament to the transparency of this familiar technology: we all know how it works, and we don't think twice about it. The interesting aside is that most optical disc systems – and some personal computers – also require users to turn the disc over manually to get data from alternate sides, while compact disc systems, and most professional PC's, have obviated this operation, either by recording data only on one side, or by designing the drive or player to read either side of the disc without intervention from users.

Although it is difficult for the naked eye to see, the groove on a vinyl record is not straight, but undulates like a stream. The disc is read by a stylus, usually with a tiny chip of industrial diamond in its head. This sensitive reading device passes along the grooved channel on the surface of the record at a constant speed (usually, of 33 or 45 revolutions per minute). As it moves, the undulations in the narrow groove create a constant flow of minute vibrations. These are picked up by the stylus and converted into a constant flow of subtly varying – i.e. analogue – electrical signals. These signals are amplified, and processed back into the sounds of words and music which we hear through the speakers or headphones.

So far, so good. We might even pause to consider that our enthusiasm for the convenience and durability of cassettes and CDs overlooks the fact that a well-made, freshly-minted vinyl record still has acoustic properties which many connoisseurs prefer to the sound of digital audio on compact discs. However, the problem with all such systems arises with time, as dust and grime collect on the exposed surface, scratches appear, and regular use inflicts unavoidable wear and tear. The flaws in the recording and the hiss of the audible interference become more pronounced, and the recording may even be so damaged as to be unplayable.

Pitched against a world of new technology, records have other drawbacks. By definition, they can only handle audio recordings – words, music and sound effects. (The various attempts to apply similar principles to video recordings are described briefly below.) The very first videodisc, produced in 1928, used the conventional shellac gramophone discs of the day, but only offered twelve grainy black-and-white pictures – hardly a video medium, then.

The storage capacity of a record, relative to its size, is also poor by comparison even to audio tape, and it is usually necessary to turn the record over midway through anything so long as a symphony or one act of an opera. And data retrieval systems for records are poor: it is difficult to pick out any one track by any method other than hand-eye co-ordination at the turn-table. All these issues are addressed by the refinements to audio-visual recording systems effected by videodiscs.

VIDEODISCS

The compact disc was the ideal product for the eighties. Its success led to the rapid growth of player and disc sales, pressing plants and production facilities. For the greedy, successful eighties, CD was the product of the future – and a hard act to follow. Multimedia products may suffer by comparison if they do not hit the ground, running, and notch up high-volume sales within months of their release.

This is not entirely fair, not only because the eighties dissolved into a worldwide recession just as the new multimedia platforms were preparing to enter the consumer and corporate markets. It is also harsh in view of the decades of research and development, trial and error which led to one immediate success (compact audio discs), some sleepers (television, colour TV), a few outright losers (quadrophonic sound, CED, VHD), and at least one also-ran (interactive video).

The term 'vapourware' was coined by cynics in the computer market to describe products which are announced, promoted – even field tested and demonstrated in public – but not actually available to the public, even for ready money. Doubt sets in, and sarcasm abounds, when a product is discussed long before it is released, and faith drops out altogether if the new offering is not seen to be successful virtually on impact.

It is sobering to reflect that the work of the Scottish inventor John Logie Baird put both television and videodiscs on the British consumer market in the late twenties. Baird's mechanical Televisor sold some 20 000 sets by the mid-thirties, before it was eclipsed by EMI's 405-line electronic broadcast system. This gave way in turn to the precursors of present standards, but it was a good 30 years before television became commonplace. Baird demonstrated a form of colour TV as early as 1927, but RCA nursed the winning formula through the fifties before the product finally became commercially successful.

Baird conceived the videodisc partly to address shortcomings of his television system, which took a long time to warm up. He designed a videodisc for a home

gramophone, with up to six minutes of grainy images, to prepare the set before the start of the broadcasts and give users something to watch outside broadcasting hours. But this Phonovision was little more than a novelty (and the discs cost seven shillings apiece, at a time when a typical old age pension was 10 shillings a week). Experiments continued apace, and at least 50 systems were developed in the next decades, but videodiscs effectively passed from view for nearly 40 years.

They were revived initially as a specialist tool for instant replays in sports broadcasting. Those 40cm/16 inch discs held only 36 seconds of video at a time, and so had to be constantly recorded, erased and re-recorded. Then, the convergence of digital data storage and laser beams finally produced the optical disc system which is the basis of both 30cm/12 inch LaserDiscs and 12cm/4.75 inch CDs.

Mechanical, electronic, capacitive, optical

Four basic approaches to data storage have been applied to videodiscs over the last century, with varying levels of success:

- Mechanical systems, such as Baird's Phonovision (and the familiar vinyl record), simply interpret variations in the movement of a stylus in a modulated groove to transmit signals which can be decoded into audio and visual information. (In the early seventies, the first modern videodisc system, Teldec, also used mechanical principles.)
- The erasable discs used for instant replays in broadcast television in the sixties employed magnetic recording technology, along the lines of audio and video tape, and various computer storage media.
- The key to capacitive systems such as the VHD and CED videodisc formats is the difference in electrical capacitance between the surface of the disc and the stylus which reads the data there.

In all these systems, direct physical contact is constantly required between the reading device and the surface of the storage medium.

- In optical systems such as LaserDisc and CD, an incandescent light source (typically, a laser), together with some form of photo-sensitive reading device, interprets data as subtle variations in the beams reflected from the surface of a mirrored disc or transmitted through a transparent one. LaserDisc and CD systems use *reflective optical discs*, but other systems developed in the seventies (such as McDonnell Douglas' own videodisc format) use *transmissive optical discs*.

One singular advantage of all optical systems lies in the use of light, rather than a stylus or other physical device, to read the data encoded on the disc. In an optical system, the fragile recording is spared the wear and tear of constant exposure, and lies sealed within the disc, to be touched only by beams of pure, fine light.

Lasers

The word laser is an acronym for Light Amplification by Stimulated Emission of Radiation. A laser is generated within a transparent cylinder which has a fully-reflective surface at one end, and a partially-reflective surface at the other. When stimulated by a high-voltage power source, waves of energy travel rapidly back and forth within the tube to produce light which is extremely pure and powerful.

The thin beam which leaves the tube through its semi-reflective end is unlike other forms of light, natural or artificial, in several ways. It is 'coherent' and 'monochromatic': that is, it emits waves which travel in phase, at one frequency – light which is, by comparison to other forms of natural and artificial light, extremely pure and consistent. (It is the range of wavelengths in other forms of light which gives us our perception of colours – laser light is all of one colour, monochromatic.)

The laser beam is so slender that it can be directed with a microscopic accuracy which makes concepts like 'pinpoint' seem large by comparison. Since laser light is both pure and strong, it can be applied to tasks which require a high degree of precision and reliability, from surgery too delicate for instruments to information storage too dense for conventional reading devices.

Lasers are also now both small and cheap, mass market items which can be integrated into other products without significantly complicating the manufacturing process, or raising the price of the goods. This was one component of the breakthrough which – 50 years after John Logie Baird's mechanical Phonovision – at last made optical videodiscs technically and commercially viable.

Optical disc formats such as LaserDisc and CD now use red lasers, but one promising area of development is harnessing the power of blue lasers. (Lasers are monochromatic, but they come in a choice of colours.) Blue lasers have a shorter wavelength than red, and could encode an optical disc up to four times more densely than the present generation of red beams. Companies including IBM and Matsushita are pursuing research in this field; in the autumn of 1991, 3M produced a prototype of a blue-green laser which sits on a single microchip. Such are the keys to meeting the demands of greedy media such as full-motion, full-screen, full-colour video.

LaserDiscs

LaserDisc – originally known as Video Long Play (VLP) and then as LaserVision – was developed by Philips, but licensed to a number of other manufacturers (including Sony and Pioneer) who supported it in consumer and professional video markets.

A LaserDisc, like an audio LP, records data in a single tightly-packed spiral groove. The critical difference is that LaserDiscs use digital encoding techniques – specifically, they store audio-visual signals not as a gently undulating stream, but as a series of shallow pits in an extremely narrow canyon. The sides of the groove in a LaserDisc recording are straight, and the width of the groove is much finer than a human hair. The length and spacing of the pits in the groove represent variations in the analogue signal.

The disc itself is made of Perspex, which combines the optical qualities of glass with the resilience of plastic. The data it holds generally begin as video recordings produced and edited on a high-quality videotape format, and then digitally-encoded at a disc pressing facility. These digital data are transferred to the surface of a fragile glass master disc, as a series of shallow pits on a spiral track, which is burnt into the disc's surface by a high-powered laser beam. A series of tough metal 'stampers' are produced from this glass master, from which the spiral of shallow pits is transferred onto the surface of blank plastic discs in the final stage of the replication process.

This delicately-patterned surface is immediately covered by a thin film of reflective aluminium, and this in turn is sealed under a transparent plastic topcoat. In this way, unlike the exposed surface of an audio LP, the densely-packed data at the heart of a LaserDisc are protected from dust and grime, scratches and damage. (They are also, like the data on an audio LP, immutable: neither disc can be erased or re-recorded.)

The shiny silver film makes the disc look glamorous, but its role is critical. Within the drive or player, the LaserDisc is 'read' by a low-powered laser beam which bounces off that reflective surface through an extremely sensitive photodiode which registers the minute variations in the length of the beams reflected from the pattern of pits on the disc. These are interpreted as digital data, to reconstruct the combination of audio and video signals (and commands to the player) which is eventually presented to us as conventional sound and pictures.

The effect of this is to increase the storage capacity of a 30cm/12 inch disc from 30-odd minutes' worth of audio on a vinyl record to an hour's worth of video on a linear videodisc. That is, so long as the disc just plays from start to finish without interruption. In fact, there are two kinds of videodiscs:

- Constant Linear Velocity (CLV) discs travel, like audio LPs, at a constant speed from start to finish and, thus, rotate more slowly when gathering data from the

outer edge of the disc than the inner. Every video frame occupies the same length of space on the disc, with more frames stored in one rotation on the outer edge than on the inner. The *Red Book*, which defines some features common to all compact disc platforms, sets scanning velocity at 1.2 to 1.4 metres per second. Thus, as CD pick-up head begins reading, 25mm from the centre of the disc, it rotates at about 498 rpm; at the outer edge 58mm from the centre, the speed is about 214 rpm.

- Constant Angular Velocity (CAV) discs take a different approach, and assign one frame of video to every revolution of the disc. The difference in speed between a LaserDisc and vinyl record is some indication of the difference in storage capacity: in the NTSC system, to produce 30 frames of video every second, the disc must rotate at 1800 rpm; in PAL and SECAM, to produce 25 frames a second, it rotates at 1500 rpm.

Thus, a CLV disc can hold about an hour's worth of video (with stereo sound) on each side, but cannot easily retrieve any one frame accurately. A CAV disc, on the other hand, holds less data but can identify each frame by a unique 'frame code' or five-digit reference number.

This is the feature which supports basic interactivity, with frame-accurate retrieval (usually, within 1.5 seconds), still and freeze frame capability, independent control of the video and two separate audio tracks and, of course, quick and slow movement back and forth through the recording. A CAV disc can hold up to 55 000 separate frames per side. This is enough for 37 minutes' worth of moving pictures in PAL or SECAM, or 30 minutes' worth in NTSC. However, CAV discs are generally dedicated to interactive video programmes, which contain a mixture of still and moving footage, and also employ computer text and graphics, so the actual playing time of any one programme may be an hour or more.

The irony of LaserDisc is that it employs encoding techniques similar to those of digital systems to record analogue video signals, without the advantages of fully digital technology. In LaserDisc, video and audio data are decoded as analogue signals; a nice distinction reserves the term 'LaserDisc' for those systems which combine analogue video with digital audio.

A LaserDisc can be single- or double-sided – although a set of three single-sided discs is sometimes called a 'three-sided disc'. Interactive video designers often divide the contents of a training course between single-sided discs so that the trainee does not have to turn the disc over in the middle of a lesson.

In fact, dozens of videodisc systems have been patented in this century – and two more (CED and VHD) are described below. There are also transmissive optical

videodiscs, in which the laser beam passes through a transparent disc to a decoding device on the other side, and discs which use magnetic rather than optical technology (somewhat in the line of the high-volume data storage disks used in computing). The possibilities are many and various, but the commercial market so far has endorsed only one product, and that with reservations.

LaserVision, the name under which this system was eventually introduced, was first demonstrated in the mid-seventies, and launched as a consumer product a few years later. It was promoted principally as high-quality medium for movies and music videos, although some simple games and entertainment packages exploited the basic features of interactivity. Pioneer 're-launched' the product in American markets in the summer of 1989, with players from $500, in an assertive bid to establish the elusive 'installed base of hardware' on which to build software and rental markets. Some 150 000 consumer players were sold that year (two-thirds of them by Pioneer), suggesting that price and functionality both contributed to the low profile of the first launch – and, possibly, that other audio-visual hardware markets were effectively saturated by the late eighties, and upmarket consumers were looking for something new to buy.

LaserDiscs are selling in the home entertainment markets of North America and Japan, but the disc's greatest impact has been in the creation of interactive video, which is discussed more fully in Chapters 2 and 3. The principles of IV, and of LaserDisc technology – as well as the commercial lessons learned in the LaserVision market, also contributed significantly to the development of multimedia systems such as CD-I.

Enthusiasts for the new range of multimedia platforms tend to dismiss LaserDiscs and interactive video as hopelessly old-fashioned. However, videodisc is still the best medium for interactive programmes which require large quantities of full-screen, full-motion video (the only kind of video which many programme-makers and users yet understand). IV delivery systems are more cumbersome than single-box multimedia packages, but the quality and quantity of the video material is excellent by comparison to any other viable technology, and it may be a few years yet before either is displaced from markets where they satisfy a real demand.

Built to last?

Some optical discs have survived some extraordinary adventures – from freezing overnight temperatures in an unheated fairground pavilion to the violence of the Challenger space shuttle explosion. Nonetheless, there is also a critical angle at which

an optical disc can be shattered, and this has been inadvertently achieved by employees of the British Post Office.

The British media were briefly engaged with the intricacies of compact disc construction after a story in the *Guardian* of 29 June 1988 suggested that oxidization of the aluminium film within the heart of the disc could cause CDs to deteriorate after eight or 10 years' shelf-life. The manufacturers replied *en force* that the discs withstood artificial aging in laboratory simulations. They also emphasized that compact discs – like records or tapes of any kind – should be manufactured in facilities of the highest technical standard, with a sharp eye to quality control, to ensure that the product works well and lasts long.

When compact disc was a new and expensive format, the few sites which offered replication services were necessarily under the direct control of manufacturers whose fortunes depended on providing products of the highest possible quality. As more facilities are established, and a wider range of replication equipment becomes available, programme-makers will be faced with the same choices as publishers and producers in other media.

While this carries the risk of shoddy products, which could do much to discredit everyone's work, it also means that, in time, there may be a choice of services for packages of different kinds – glossy and expensive for the electronic equivalent of the coffee table book, with lots of movement and colour and a long shelf-life, but faster and cheaper for just-in-time training or games which have to reach the market quickly to exploit a passing craze.

The best approach is ensure that discs are pressed to the highest standards and to treat all media with respect:

- Protect all hardware and software from extremes of heat and cold, excessive humidity and strong light.
- Keep all media within protective covers whenever possible, and handle only the rigid outer edges – hold a book by its spine, a cassette by its corners, a disc at its edges.
- Keep all foreign bodies – greasy fingers, cigarette ash, crumbs, liquids – well away from exposed surfaces such as the tape in audio and video cassettes, the holes in computer disks, or the shiny surface of LaserDiscs and CDs, and the controller, keyboard, screen and other components of the delivery system.

With due care and attention, a LaserDisc or CD may last a long time. No one really knows how long, because few have been in circulation for more than ten years, and

there is not yet a substantial body of research or observation to report. So far, it seems entirely likely the discs will last as long as there are systems to read them.

The irony is that, however durable the disc, everything in a multimedia system but the printed user's manual is 'machine readable only' – you can discover nothing of its contents without the appropriate machine(s) through which to process its coded data. The industrial archaeologists of the future will have to struggle to reconstruct our machines – aided, perhaps, by a few brittle fragments of dog-earred manuals - before they can begin to analyse the legacy of our multimedia programmes. If your office block collapsed tomorrow, the chiselled foundation stone outside would probably preserve more immediately intelligible information than the whole of the data processing department.

Of course, should the appropriate machines survive elsewhere, anything recorded on a compact disc stands a very good chance of recovery even under these extreme hypothetical conditions. Realistically, CD-I discs should be equal to the shelf-life of their contents, be that an adventure game or archival data. To appreciate the benefits of this durability, consider for a moment an alternative approach to videodisc technology which was very fragile indeed.

Capacitive videodiscs: CED & VHD

Although the concept of videodisc is now synonymous with LaserDiscs, two 'capacitive' videodisc systems once competed for a share of the videodisc market. Both were launched around the same time as LaserVision, in the early eighties. Both combined digital encoding methods with the principles of capacitive disc systems to record sound, pictures and technical data on a disc.

RCA developed Capacitive Electronic Disc (CED) or SelectaVision, the 'grooved' capacitive disc. JVC developed Video High Density (VHD), the 'grooveless' capacitive disc. There were fundamental differences between the two formats, and neither was compatible with the other, nor of course, any other videodisc system. However, they both explored the same idea, of packing a dense audio-visual recording (similar to that on a videotape) onto the surface of a disc, and reading this with a head which maintained physical contact with the recording.

CED had extremely fine grooves on the surface of the disc, but rested the reading head on the sillions between them, so that the head did not actually touch the recorded surface of the disc. VHD dispensed with the grooves. In both, the surface of disc was so tightly packed with a fine stream of recorded data that the disc itself had to be

protected from exposure at all times. Both employed a rigid plastic caddy which covered the disc when it was outside the shelter of the player.

Neither system easily supported the rapid random access which is the essence of interactive systems, lacking the precision of LaserDisc in retrieving specific data such as single frames of video. (Furthermore, while CED was fairly resilient as a linear medium, the disc was actually damaged by the impact of the reading head, as it moved from one part of the recording to another, in interactive applications.) And, like other videodisc systems, both recorded commands for the interactive control program on the disc itself, alongside the audio-visual data. These messages were as vulnerable as the audio and video signals, and deteriorated in much the same way as the sound and picture quality. Thus, a well-worn VHD programme displayed a kind of technological pre-senile dementia, breaking up on screen and jumping erratically from point to point.

Both had some success as home entertainment – mostly, for movies or music videos – but their impact as professional communications products was negligible. VHD was used for a handful of interactive video applications in the UK in the early eighties, mostly in education and training. The content of some was good, but even where the level of interactivity was low, the performance of the system was poor.

There are some VHD systems still in the British schools, but the format had little impact in the nascent European market, nor in North America, and THORN EMI, who promoted the system in the UK, have since diversified into the larger multimedia market. Conversely, CED was aimed primarily at the consumer markets of the US and Japan, although both consumer and professional versions of the system were launched in the UK just before RCA finally decided to cut their losses, in April 1984.

In May 1984, the *Videodisc Monitor* reported that 'about 550 000' players had been sold in the three years since the launch of the system in March 1981 – and that, in the last six months, most had sold for less than $200, in a last bid to create an installed base of hardware on which to build software sales. (This compares to worldwide sales of over 350 000 CD audio players in their first year on the market, 1983, and of about 14 million within three years.) In January 1984, the *Monitor* reported that the best-selling CED disc, the film *On Golden Pond*, had clocked up 69 800 sales.

By April 1984, the *Monitor* reported, RCA had sustained cumulative losses on CED of some $580m, on research and development, manufacturing, marketing and attendant costs. Production of both players and discs was quickly phased out, and ceased altogether by the end of 1986.

For the world at large, the best things to come out of the débacle were Margaret Graham's study, *RCA & The Video Disc: The Business of Research* (Cambridge

University Press, 1986), and a series of articles and comment in the spring 1991 issues of the renamed *Multimedia & Videodisc Monitor*. These formed part of an occasional series called 'Tales from the Crypt', in which old multimedia hands recount projects gone wrong, and try to draw morals. From the CED story, Stan Williams (in April 1991) extracted four nuggets of pertinent advice:

- Trust common sense, not sales literature.
- Don't blame your competition for being less than perfect when you're far from perfect.
- Field test your product before you sell it.
- Remember, customers expect more, not less.

Stan Jarvis replied to Williams' article in June 1991. He observed that CED was released without a feature common to all comparable products – in this instance, mono sound when VHD, LaserVision and videotape all offered stereo. He also noted how essentially positive trends were interpreted negatively by a nervous market (such as the decision to stop manufacturing reading headers – not, as was assumed, for lack of faith in the product, but simply because the heads in the first players proved more reliable than expected, and there was no immediate demand for replacement parts).

Jarvis added three more suggestions:

- If you are going to do something new, do it right from the very beginning.
- Do not buy any technology before its time.
- When it comes to hardware, don't be penny wise and pound foolish.

This is sound advice in any market, which software publishers and hardware manufacturers would do well to heed. There may be a lesson in the history of CED and VHD, but there is no guarantee that similar stories will not unfold again.

COMPACT DISCS

Compact discs can be used to store audio, computer data, video signals, or virtually any combination of these in various forms. The disc itself is essentially the same whether it holds an opera or an encyclopedia. The features of its various applications, to audio, data or multimedia systems, are discussed in Chapter 3, Multimedia Titles.

The compact disc is a refinement of the original 30cm/12 inch reflective optical laser disc, LaserVision. CDs are compact by comparison to that earlier medium: 12cm/4.75

inch in diameter, 1.2mm/.005 inch thick (less than half the videodisc's 2.7mm). CDs, like interactive LaserDiscs, employ the CLV (Constant Linear Velocity) format. Functionally, this means that the disc does not travel at a constant speed from start to finish, but varies between the short journey at the centre of the disc and the wide circumference of its outer edge.

- Conventional audio LPs travel at the same 'angular velocity' from start to finish, at a rate of 33, 45 or 78 rpm.
- CAV videodiscs, by comparison, spin at 1500 or 1800 rpm.
- CLV compact discs vary from 214 to 498 rpm.
- Linear LP recordings start at the outer edge and move in, where CDs start at the inside and finish at the outer edge.

CDs, like LaserDiscs, record all data in a stream of brief digital signals, which are represented as a pattern of tiny pits in a narrow, straight-walled spiral. An audio LP, by contrast, records a continuous analogue signal in a broad, undulating groove. (See Appendix 1 for the distinction between analogue and digital.)

The groove on a CD is some 60 times finer than that of an LP, with a pitch of only 1.6mm (a micron or micrometre is one one-thousandth of a millimetre.) The individual pits which carry the digitized information are uniformly 0.5mm wide and 1.0mm deep, varying in length from 1.0mm to 3.0mm. The tightly-packed spiral track on the surface of the disc would extend for some five kilometres, or about three miles, could it be unspun like a silk worm's cocoon.

Fortunately, a compact disc is manufactured in the same way as a LaserDisc, and so enjoys the same protection from wear and tear. Even if the disc were scratched, the precise angle and narrow focus of the laser beam in the player may not be distracted by surface damage as it searches for data stored in the central layer of the disc. (On the other hand, dirt and smears can cause reading errors in the drive or player, which can usually be remedied by gently cleaning the disc.)

One form of compact disc, CD-Video, is effectively a smaller version of the analogue LaserDisc. But the particular strength of most CD formats, from CD-ROM for data storage to CD-DA for audio and CD-I for multimedia, is the use of digital data for all applications. This improves functionality, storage capacity and processing power, and facilitates the exchange of discs between countries which employ incompatible technical standards for television, video and other communication systems.

Another important feature of compact disc technology is embodied in the principle of upward compatibility – that new and more complex CD platforms should, as far as

possible, also handle data from earlier formats. Thus, a CD-ROM drive for computer data can (with headphones, or an amplifier and speakers) also play CD-DA audio discs, and CD-ROM XA systems (which improve the functionality of the CD-ROM platform) can handle CD-ROM and CD-DA discs. CD-I, similarly, will play ordinary CD-DA audio discs. The blur of acronyms is confusing at first: the main point to remember is that current systems can sometimes be upgraded, and new systems can often play all the software purchased for older equipment. This principle encounters some problems in complex professional markets, but for consumers, the advantages are obvious.

The various ways in which the essence of compact disc technology is applied to these diverse platforms are discussed in Chapter 2, Multimedia platforms.

Appendix 3

Glossary

Access • The reading or writing of data on a storage medium, or the retrieval of recorded data, measured in 'access time' (cf. seek time).
Access controller • The component in a CD-I drive which controls the flow of data to the video decoder.
Active regions • *See* hotspots.
Adaptive Differential Pulse Code Modulation (ADPCM) • An adaptation of 16-bit PCM, specially developed to support CD-I's three additional audio levels, which records sound with eight and four bits per sample, in mono or stereo.
Address • The physical location of data in memory or on a storage medium; in CD systems, every sector has an 'absolute disc address' locating it in terms of minutes, seconds and sectors from the start of the disc. 'Addressable data', having uniquely identifiable locations, can be accessed randomly (and, thus, interactively), unlike data which can only be approached sequentially.
ADPCM • *See* Adaptive Differential Pulse Code Modulation.
ADPCM decoder • The decoder within the CD-I player which converts ADPCM audio in four or eight bits for output as 16-bit PCM digital audio.
Alias • An undesirable false value in a digital sample, which supplies an artificially calculated value in place of one which the system cannot easily interpret.
American Standard Code for Information Interchange (ASCII) • A standard 7-bit code (i.e. one with 128 patterns) for encoding alpha-numeric and other characters for exchange of data between disparate computer-based systems.
Analogue • Describing data from the natural world (such as temperature, voltage or current) that are constantly fluctuating in amplitude and time.
Anti-aliasing • A technique for improving digitized data that substitutes acceptable new values for data which would otherwise be misrepresented by unacceptable false

values or 'aliases' and, thus, distort the audio signal or image being delivered to the output devices.

Application • A specific activity or topic to which a computer program or software package is dedicated; hence, applications software, which is written for a particular task or project.

APU • *See* Audio Processing Unit.

Artifacts • Minute errata, often introduced during digitizing, which may distort digitized data.

ASCII • *See* American Standard Code for Information Interchange.

Aspect ratio • The relative proportions (height/width) of a two-dimensional datum such as a pixel or area such as a screen.

Assets • The various data (audio, video, program-related) which comprise the contents of a CD-I disc.

ATM • Automated teller machine, the hole-in-the-wall 'cash dispenser'.

Attractor loop • An invitation (typically, in a point-of-sale system) that plays continuously until interrupted by a request to start the interactive presentation.

Audio channels • The 16 of CD-I's 32 data channels which can carry audio signals.

Audio functions • Functions within the User Communications Manager (UCM) specifically concerned with ADPCM audio data.

Audio levels • *See* Level A, Level B, Level C.

Audio Mixing Control Unit • The component within the Audio Processing Unit (APU) of a CD-I drive which adjusts volume and balance between left and right output channels.

Audio Processing Unit (APU) • The component in a CD-I drive which converts digitally-encoded data from a CD-DA or CD-I disc into analogue signals for the left and right output channels of devices such as speakers or headphones.

Authoring software • High-level computer programs that allow users to work with everyday words and concepts to create interactive presentations in CBT, IV or multimedia systems; the authoring software itself translates these commands into the lower levels of programming needed by the computer and related hardware devices.

Auxiliary data field • The last 288 bytes in a CD-ROM or CD-I data sector, where the extra error protection codes are stored in Mode 1 and Mode 2, Form 1 (and any data can be stored in Mode 2, Form 2).

Backdrop plane • The hindmost of CD-I's four image planes, which displays a monochrome background in a choice of 16 colours, video from an external source (e.g. a videodisc) or full-motion, full-screen video when this feature is available on CD-I.

Background plane • *See* Backdrop plane.

Bandwidth • The range of signal frequencies, measured in cycles per second – Hertz (Hz) and mega-Hertz (mHz) – to indicates how many data a channel can pass at one time.

Base case • The minimum specification for a delivery system in a platform such as CD-I.

BER • *See* Bit Error Rate.

Bespoke • Custom-made on commission for a client by a supplier.

Betacam • A videotape system, developed by Sony, which holds both audio and video recording equipment in a single lightweight 'camcorder'.

Binary • A notational system in which there are only two possible values (e.g. 0 and 1, on and off), widely used in electronic devices to transmit and process large volumes of data quickly and accurately.

Bit error rate (BER) • A measure of the frequency with which errors typically occur in a data channel (CD-ROM and CD-I, with three levels of error protection, have a BER of one error per 10^{18} bits).

Bit mapping • An encoding method which assigns a discrete value (of one or more bits each) to every pixel in an image.

Bits and bytes • The smallest discrete elements in a binary system: eight 'bits' (binary digits) comprise one byte ('by eight'), a kilobyte (KB) comprises 1024 bytes (2^{10}), a megabyte (MB) comprises 1 048 576 (2^{20}) bytes, a gigabyte (GB) comprises 1 073 741 824 (2^{30}) bytes, a terabyte comprises 1 099 511 627 776 (2^{40}) bytes.

Black box • A discrete hardware component which effects communication between two disparate pieces of equipment.

Block • In CD-ROM and CD-I, that portion of a sector devoted to data for the user (rather than headers, error correction codes and other system data), identified by a block address, which is converted into the absolute disc address unique to every sector.

Board (or card) • A small flat piece of plastic resin which carries electronic components such as chips and the circuits that connect them, either fixed (like the motherboard that carries the computer's central processing unit) or plugged into special slots to support various special facilities.

Bookmark • A facility to mark or 'flag' places (automatically or optionally) to which users may later wish to return during their exploration of an interactive presentation.

Boot • To start up a computer-based system (typically, from instructions stored in ROM that are loaded immediately the power is turned on.)

Boot Record • *See* Disc label.

Branching • To move from a decision point, such as a menu or question, to that part of the interactive program which responds most logically to the user's choice.
Bugs • Errors or flaws in a computer program or system, which are corrected or removed by 'de-bugging'.
Bundle • To supply another product (hardware or software) with a larger system, at no external cost.
Bytes • *See* Bits and bytes.
C • A popular general purpose computing language that combines the convenience of a high-level language with facility to write at lower levels (for example, to address specific hardware devices).
C-format • A popular broadcast-quality one-inch videotape format, which supplies analogue video recordings of good quality for conversion to digital media.
Capacitance Electronic Disc (CED) • A capacitance videodisc system (i.e. which records audio-visual data as variations in capacitance, the ability to store an electrical charge) developed by RCA, launched as SelectaVision in the seventies, but withdrawn from the market in the mid-eighties.
Card • *See* Board.
CAV • *See* Constant Angular Velocity.
CD • *See* Compact Disc.
CD+G • *See* Compact Disc Plus Graphics.
CD-DA Decoder and Controller • Those components of the CD-I player which decode 16-bit PCM data from a CD-DA disc and send these directly to the audio processing unit. The CD-DA controller also provides high-level error protection for CD-DA and low-level protection for CD-I data.
CDFM • *See* Compact Disc File Manager.
CDTV • *See* Commodore Dynamic Total Vision.
CED • *See* Capacitance Electronic Disc.
Central processing unit (CPU) • *See* Main Processing Unit.
Check disc • The prototype of an optical disc, usually produced through a WORM disc-cutting facility, which can be used to test and adjust the contents of the disc and any related software or hardware before discs are replicated in volume at a pressing facility.
Chip • A fragment of a crystal of semiconductive material (usually crystalline silicon), photographically imprinted to create a semiconductor device or integrated circuit.
Chroma key or colour key • A special effect produced by shooting figures or objects against a monochrome (usually, blue) background, which is later replaced by images

from another source, so that the foreground images look as though they were shot against a background which is actually quite separate.

Chrominance • The hue and saturation (i.e. colour and intensity) of an image, expressed as the signals U and V, which complement Y, or luminance (radiance).

CIRC • *See* Cross-Interleaved Reed-Solomon Code.

Clip • In AV production, a short piece of audio or video material; in computer graphics, to select only designated parts of an image for special treatment, copying or moving to another location.

CLUT • *See* Colour Look-Up Table.

CLV • *See* Constant Linear Velocity.

Colour key • *See* Chroma key.

Colour Look-Up Table (CLUT) • A table that assigns a discrete value to every colour available at any one time, so that graphics can be encoded quickly using these convenient table addresses rather than the less accessible 'absolute values' of the entire RGB colour range. CD-I uses CLUT locations to support graphics in normal resolution with 256 colours (8-bit or CLUT 8) or 128 colours (7-bit or CLUT 7), and in high resolution with 16 colours (4-bit or CLUT 4). A CLUT 8 image requires 105KB in PAL/SECAM and 90KB in NTSC, a compression ratio of 3:1 over RGB 8:8:8 at normal resolution.

Colour standard • One of three international specifications (NTSC, PAL and SECAM) that dictate how colour TV or video pictures are produced and transmitted.

Combi-player • A player which can handle two or more incompatible optical disc formats or sizes (typically, LaserDiscs and compact discs).

Command-driven • A system that requires users to write instructions in words or codes, rather than respond to prompts from menus or graphical user interfaces (GUI); command-driven systems tend to require a high degree of training and accuracy.

Commodore Dynamic Total Vision (CDTV) • The interactive multimedia platform developed by Commodore, by combining features of an Amiga home computer with CD-ROM drive, to support graphics, text, limited moving footage, and stereo sound.

Compact Disc (CD) • A high-density digital data storage medium employing a 12cm/4.75 inch reflective optical disc; immutable 'silver' CDs are produced only at pressing facilities, 'gold' discs can be recorded locally or even in-house (typically, by their users) with special disc cutting equipment.

Compact Disc Digital Audio (CD-DA) • The compact disc format for top-quality PCM audio, which holds around 72 minutes of sound on one side, with universal technical specifications defined by the *Red Book*. A CD-DA disc comprises 75 frames

(i.e. sectors) of audio data, and eight sub-code channels (P to W) for data which can include simple text and graphics.

Compact Disc File Manager (CDFM) • The file manager within CD-RTOS which translates high-level commands from the CD-I disc into instructions for the various low-level device drivers which control the flow of information to the delivery system.

Compact Disc Interactive (CD-I) • The interactive multimedia platform developed by Philips (and supported by Sony, Matsushita and other manufacturers), based on a Motorola 68000 processor and compact disc drive, with universal technical specifications defined by the *Green Book*. CD-I supports three levels of audio (Levels A, B and C) in stereo or mono, four graphics formats (DYUV, RGB 5:5:5, CLUT and RLE) at various levels, four image planes (cursor, Planes A and B, and backdrop), in/out devices including a remote control unit and keyboard, and output to ordinary televisions and hi-fi systems, under its own dedicated operating system, CD-RTOS.

Compact Disc Plus Graphics (CD+G) • The compact disc format which complements a CD-DA audio recording with text and graphics stored in one or more of the disc's six spare sub-channels (R to W).

Compact Disc Read Only Memory (CD-ROM) • The compact disc format principally devoted to text and data (and, occasionally, audio and graphics), according to the technical specifications of the *Yellow Book*, and ISO-9660 ('High Sierra').

Compact Disc Read Only Memory Extended Architecture (CD-ROM XA) • The enhancement of the CD-ROM format (as an extension of the *Yellow Book*) which employs ADPCM audio, and interleaving, to effect more responsive handling of multimedia databases combining sound and pictures with text and data.

Compact Disc Real-Time Operating System (CD-RTOS) • The unique CD-I operating system, based on OS-9, and enhanced to support multi-tasking in real-time multimedia environments. The kernel at the heart of CD-RTOS controls initialization, multi-tasking, input/output, service requests, memory management, and interrupts.

Compact Disc Video (CD-V) • *See* LaserDisc.

Compression • Various coding methods that reduce the space and/or processing required to record, store and reconstitute data of different kinds, typically by reducing the quality of the record (e.g. taking smaller or less frequent digital samples), or by minimizing redundancy (e.g. by recording the first image in a sequence of moving footage, and then noting only changes in the frames which follow).

Concept keyboard/keypad • A touch-sensitive pad that can be covered with any number of changeable plastic or paper overlays, designed to identify hotspots with icons, objects, labels, keys, maps or other navigational devices in text or graphics.

Configuration • In computer-based systems, a specific combination of equipment.
Configuration Status Descriptor (CSD) • The function which identifies all the equipment under the control of the CD-RTOS kernel – by type, name, status (i.e. idle or active) and specific technical parameters – to determine the exact configuration and capacities of any one delivery system.
Constant Angular Velocity (CAV) • Discs that spin at a constant speed and assign one frame per revolution (each frame thus having a slightly different track length to those before and behind it); also known as 'active play' discs, for their ability to support rapid random access within interactive systems.
Constant Linear Velocity (CLV) • Discs that assign a fixed track length to every frame or sector (so that more are read in one revolution around the outside edge than at the centre), and thus spin faster at the outside edge, slower inside.
Consumer market • The 'domestic' users who usually need or prefer products which are cheaper, smaller, lighter, simpler and/or more entertaining than those for the professional 'corporate' market.
Corporate video • Non-broadcast video, typically made for training, communications or marketing, either for use in-house or publication to other professional environments.
CPU • *See* Main Processing Unit.
Cross-Interleaved Reed-Solomon Code (CIRC) • A combination of two of computing's Reed-Solomon (RS) correction codes, specially adapted for compact discs, to identify and conceal 'burst errors' (that is, where the first and last digits of the binary code can identify the exact location of corrupt data). The CIRC encoder employs two stages of coding and three of interleaving to detect errors and interpolate projected values to conceal them. CIRC can correct errors of up to 4000 data bits (or 2.5mm of track) and conceal errors of up to 12 304 data bits.
CSD • *See* Configuration Status Descriptor.
Cursor • A static or flashing shape on the computer or multimedia screen that indicates where users can make selections, effect actions or input data. CD-I has a separate cursor plane (16 pixels by 16, with a choice of 16 colours) which can move anywhere on the screen under the control of an X-Y pointing device.
Cut • The visual effect in which one scene or image follows another directly (i.e. with no gradual transition between them).
Cut-and-paste • A routine for copying or moving information from one location to another in a computer-based system, identical in principle to the paper-and-glue metaphor for which it is named.

DAT • *See* Digital Audio Tape.

Data channels • The 32 discrete routes through which all data in the CD-I are streamed; 16 carry data of all kinds (audio, video, program-related and program code), the other half carry all but audio data.

DCP • *See* Display Control Program.

Decoder • A device which accepts encoded data and processes these for output to another device which cannot accept the encoded form.

Dedicated • Hardware, software or functions designed specifically for one particular use or application.

Definition • *See* Resolution.

Delivery system • The combination of hardware and software necessary to present or employ programming in any given format: the CD-I delivery system minimally comprises a CD-I drive or player, a television or monitor, and at least one input device (such as a remote controller).

Delta (Δ) • The Greek letter D, mathematical symbol of a finite increment in a variable.

Delta YUV • A digital encoding technique that assigns a value to the luminance signal (Y) of each pixel in a RGB graphic, and then defines hue (U and V) relatively: Y comprises 0.6G + 0.3R + 0.1B, U = Red–Y, and V = Blue–Y. DYUV assigns a Y value to every pixel, but calculates U and V values for pixel pairs. DYUV requires 105KB in PAL/SECAM and 90KB in NTSC to support up to 16 777 216 colours with a compression ratio of 3:1 over RGB at normal resolution (Quantized High-Resolution Y supports high resolution). DYUV is well suited to 'natural' photographic images.

Density • The compactness or density of data storage on a medium such as a magnetic disk or optical disc.

Device-dependent • Requiring specific hardware elements to supply input or effect output.

Differential Pulse Code Modulation (DPCM) • An adaptation of PCM which transmits only the difference in the value of the current sample from that which immediately preceded it (which, therefore, requires less data than PCM, which transmits the same amount of information about every sample, no matter how similar to those which preceded it).

Digital • Describing systems used in most computer and some optical disc technology, which process information – including text, graphics and audio-visual signals – as a numeric (usually, binary) code. By reducing all information to a series of fixed numeric values, digital data tend to be more precise, consistent and manageable than analogue data, and are thus preferred for use in computer-based systems.

Digital Audio Tape (DAT) • A high-quality high-density storage medium that adapts the helical scan of videotape systems, with additional error protection codes, to store digital data (including audio and, experimentally, video) on magnetic tape.

Digital Video Interactive (DVI) • A technology developed, in turn, by RCA, General Electric and Intel (with IBM, Matsushita, Olivetti and others), to provide a set of compression algorithms in a chipset (and, ultimately, on the motherboard of a desktop computer) to encode and decode video from media including hard disks and optical discs. DVI technology supports three video encoding techniques at various levels of quality for still and moving images.

Directory • The larger file within which a collection of individual data files are held; directories within directories are called sub-directories.

Disc and disk • 'Disc' tends to be the preferred spelling for optical media such as videodiscs and compact discs, and 'disk' for magnetic media such as floppy disks and hard disks.

Disc label • Data in the first track of a CD-ROM or CD-I disc, comprising the File Structure Volume Descriptor (which describes the structure of files on the disc), an optional Boot Record (which points to the Boot File, if the system is to boot up from the disc itself), and a Terminator Record (which marks the end of the label). The disc label is always recorded in Mode 2, Form 1.

Display control program (DCP) • The program (controlled by the UCM) which regulates every field scan to manage the display of images on the screen, and produces special effects.

Dissolve • A special effect in which one image appears to melt or fade into another, as one grows fainter and the other, stronger.

DOS • *See* MS-DOS.

DRAM • *See* Random Access Memory.

Drawmap • A block of memory allocated by the User Communications Manager (UCM) to store data for an image temporarily in one of CD-I's two memory banks.

Drive or player • The peripheral or internal hardware device that holds an optical or magnetic storage medium such as a computer disk or optical disc.

Driver • The routine within an operating system that communicates directly with one specific piece of hardware in the delivery system; the operating system and applications software often employ high-level languages which drivers must translate to the low-level code employed by hardware devices.

DVI • *See* Digital Video Interactive.

Dynamic Random Access Memory (DRAM) • *See* Random Access Memory.

Dynamic update • Fresh data supplied, often in real time, while the system is running (for example, to cycle between CD-I's four possible colour look-up tables, to increase the number of colours available in an image, or create the illusion of movement).
DYUV • *See* Delta YUV.
ECC • *See* Error Correction Code.
EDC • *See* Error Detection Code.
Electronic publishing • Data services provided entirely though computer networks, or on machine-readable media such as magnetic disks or optical discs.
Emphasis • A technique to improve the signal-to-noise ratio (to reduce distortion in the data channel, such as audible 'white noise' or 'hiss'), by increasing the level of higher frequencies relative to lower ones, before recording or transmitting a signal.
Emulator • A sub-system with an industry-standard SCSI bus which passes data (typically, from the hard disk of an authoring workstation) to a CD-I player as though the signals were coming directly from a CD-I disc, for testing and evaluation, and even to pre-master the tape from which the disc itself is eventually produced.
Encode • To convert data into a numeric code (which may, subsequently, have to be decoded for transmission or output elsewhere).
End-of-file bit/End-of-record bit • Bits in the sub-header which mark the end of a real-time file or record, respectively.
End-user • The person who actually interacts with a computer-based product at work, in training or for any other purpose.
EOF bit/EOR bit • *See* End-of-file bit/End-of-record bit.
EPROM (Erasable Programmable Read-Only Memory) or EEROM (Electrically Erasable Read-Only Memory) *See* Read-Only Memory.
Erasable • A recording medium (such as audio or video tape) that can be erased or overwritten, unlike pre-recorded or WORM media which, once recorded, are effectively immutable.
Error concealment • Techniques that supply alternative data to replace errata (typically, by repeating correct data, or creating plausible new data from the values of adjacent, error-free signals).
Error Correction Code (ECC) • The part of CD-I's data protection routine which replaces incorrect bits with acceptable bits copied or extrapolated from correct data.
Error Detection Code (EDC) • The part of CD-I's data protection routine which identifies errata.
Event • A discrete activity or routine, typically involving interaction between the user and the system.

Executable • Describing codes or instructions which the system can interpret to initiate activities or routines.
Expert system • A data processing system with special expertise, often based on human knowledge and experience, which can diagnose, solve problems and, often, justify its decisions by citing precedents.
Extension • The enhancement of a product or technical specification to effect improvements or provide optional features; also, the second part of certain computer-based naming conventions (such as the three characters after the point in DOS systems – e.g. 'letters.doc').
Fade • A special effect in which images or regions on the screen gradually grow stronger (fade in) or weaker (fade out).
Field control table • A set of data within the Display Control Program (DCP), containing up to 1024 separate instructions for the display of every field in video sequence (executed 60 times per second in NTSC, and 50 times per second in PAL/SECAM).
Field testing • Trials of prototypical or completed hardware and/or software amongst selected target audiences or wholly inexperienced users.
Fields • The two, interlaced, scans which comprise one full frame of video: at full-motion, NTSC requires 30 frames or 60 fields per second, and PAL and SECAM require 25 frames or 50 fields per second.
File • A set of related data, analogous to the light cardboard sleeve in which papers or documents are held in a conventional filing system.
File descriptor record • Data within each directory, which specify the name, number, size, address, owner, attributes, interleave instructions and access permissions to read for every file in the directory .
File managers • CD-RTOS software programs which control the retrieval, processing and display of CD-I data of various kinds; the essential Compact Disc File Manager (CDFM), Non-Volatile RAM File Manager (NRFM) and User Communications Manager (UCM), can be complemented by the optional Network File Manager (NFM), Random Block File Manager (RBF) and Sequential Character File Manager (SCF).
File protection • Techniques to limit access to, or use of, selected files (typically, by the use of passwords or codes).
File Structure Volume Descriptor • *See* Disc label.
Flat artwork • Conventional graphics produced on paper or board through media such as paint and pens.

Floppy disk • The removable magnetic storage medium (typically, 13cm/5.25 inch or 9cm/3.5 inch) commonly used by desktop computers.
Flowchart • The schematic image of a computer program which illustrates the relative positions of assets (in CD-I, audio, video and program-related data) and activities (such as input and decision points), to illustrate the structure of the presentation and the potential interactive paths through its contents.
Font or fount • A set of alpha-numeric characters and symbols designed in one style and one size, measured in print as points and picas (12 points to a pica, 6 picas to an inch), in computer graphics as pixels, and in video as lines per character.
Form 1/Form 2 • *See* Mode 2.
Form bit • A bit in the sub-mode byte of the sub-header which defines the Form (1 or 2) in which Mode 2 data are recorded.
Format • As a noun, the physical characteristics, technical specifications, or structure of data which define specific hardware and software products and encoding techniques; as a verb, to prepare data or media according to specific technical criteria.
Fourth Generation Language (4GL) • High-level computer languages accessible to people without formal programming skills, with features such as icons, objects, help facilities, pull-down menus, dialogue boxes, and templates which present authors with options for every activity which they are likely to pursue. The software itself generates the program code required to translate these instructions into the commands which the operating system and device drivers require.
FPS • Frames per second – *see* Frame rate and Full-motion.
Frame • A single still image in a film or video sequence; the two interlaced fields which make up one screen of analogue video; the array of bits across the width of a computer tape; or the block of data in CD-DA equivalent to CD-I's 'sector'.
Frame grabber • Hardware that converts individual images, from analogue video or conventional artwork, into digital data.
Frame rate • The speed at which moving video sequences move, expressed in the number of full frames (i.e. discrete still images) projected per second.
Freeze frame • A single, static image arrested on screen from a sequence of moving footage.
Full-motion • Film or video run at standard speed, to simulate seamless moving pictures; modern cine film runs at 24 frames per second, NTSC video at 30, and PAL/SECAM video at 25.
Generations • The number of copies between an analogue signal and its source or the recording on which it is based (with a consequent loss of quality in each successive

copy); also, the relative level of a hardware or software product which is regularly upgraded (e.g. Version 2.01) or, more broadly, the era or quality of products within which a hardware or software product is classed (e.g. fourth-generation languages).
Generic • The term used of commercially-produced IV software or courseware which can be purchased or hired 'off-the-shelf'.
Genlock • Hardware which synchronizes discrete visual signals (such as video images and computer-generated text) by locking their separate pulses to a common beat.
Gigabyte • *See* Bits and bytes.
Glass disc • *See* Master disc.
Global • Comprehensive or universal (e.g. a routine which affects all the data in a given set, or characteristics common to a set of data).
Granulation • *See* Mosaic.
Graphical user interface (GUI) • Communications between people and computer-based systems which make extensive use of visual and textual prompts and *aides-memoire* – in the form of icons, objects, labels, pull-down menus, windows and similar devices – rather than the codes and text of command-driven and menu-driven systems.
Graphics cursor functions • That aspect of the UCM which controls the size, shape, colour and position of the cursor on the screen.
Graphics drawing functions • That aspect of the UCM which provides basic run-time drawing and text features such as line, rectangle, polygon, circle, ellipse, arc and fills, with a choice of patterns, colours and line widths.
Green Book • The universal functional specification for CD-I. (Also used as an adjective, as in 'green data', i.e. conforming to the standards set by the *Green Book*.)
GUI • *See* Graphical user interface.
Hard disk • A rigid magnetic disk (such as those used in IBM's Winchester technology), often built into a computer to provide a large volume of data storage.
Hardware • The physical elements of computer-based systems, including internal components such as chipsets and boards, in/out devices such as monitors and keyboards, and consumables such as floppy disks and tape.
HDTV • *See* High Definition Television.
Head or stylus • The part of a player or drive that reads and/or writes and/or erases data recorded on a medium such as a magnetic disk or tape, or optical disc.
Header • The eight bytes of data in every CD-I sector which record the sector's address in relation to the start of the track, the Form and Mode in which the data are recorded (and, for Mode 2, information to assist in de-interleaving data for output to the appropriate channel).

High Definition Television (HDTV) • Broadcast TV standards (such as the Japanese MUSE, with 1125 lines per screen, or the European HD-MAC, with 1250) which produce images at least twice as sharp as the current 525-line NTSC, and 625-line PAL/SECAM standards.

High Sierra • The *ad hoc* committee of hardware, software and publishing interests (which first met at the High Sierra Hotel on Lake Tahoe) which drew up the recommendations adopted as ISO 9660.

High-level • *See* Language.

Hotspots • Areas on the screen (typically identified by icons, objects, keywords or other distinctive symbols) which are programmed to initiate specific actions or responses if selected by the user.

HyperCard • An object-oriented authoring and presentation package launched by Apple with their Macintosh computers to encourage users to create interactive multimedia presentations.

Hypermedia • The principles of hypertext extended to multimedia platforms and products.

Hypertext • Software programs which allow users to explore one or more thematically-linked databases through the use of keywords, searches, and/or graphical user interface.

I/O • In/Out or Input/Output (i.e. actions and devices which effect communication and the exchange of information between people and machines).

IBM-compatible • Hardware and software products based on the *de facto* standards established by IBM's personal computer range.

Icon • A pictogram, usually small in size and simple in design, which represents (on its own, or with a brief descriptive label) an option or activity which users can choose or initiate by selecting (i.e. activating) the pictographic symbol – for example, to open a file by clicking on the icon of its folder.

Image plane • In CD-I, one of the four adjacent vertical surfaces – the cursor plane, Planes A and B, and the backdrop plane – on which visual data of various kinds can be displayed.

Industrial • *See* Professional.

Input • Data, requests, choices or responses provided to a system by its users, typically from an input device such as a keyboard, mouse, touchscreen or remote control unit.

Integrated • Internal, built-in or wholly compatible.

Interactive • Of hardware and software systems which can respond to input from users: minimally, by offering a limited range of options and choices (as in a remotely-

controlled VCR), ultimately, by providing a variety of resources which allow users to act spontaneously, and react constructively, to explore a body of knowledge and create a dialogue between the user and the system.

Interactive Video (IV) • Information systems which typically combine sound and pictures from a video disc or tape with the text, graphics and processing power of a desktop computer or built-in micro-processor – generally, in a delivery system which also includes a monitor and input devices such as a keyboard, mouse or touchscreen.

Interface • The point of contact between two systems, devices, programs, or between users and machines; and, thus, the hardware and software which effect communications between two disparate bodies.

Interleave • To arrange data of different kinds (e.g. audio, visual, program-related) so that information is recorded, retrieved and processed smoothly and efficiently.

International Standard Recording Code (ISRC) • The format used in the music industry to display catalogue and serial numbers, year of issue, owner and country of origin (recorded on Channel Q of a CD-DA disc).

Interpolation • Techniques to conceal errors, or extend the use of data, by inserting artificial or redundant information between known or correct values.

Irregular update • A partial-screen update where the region within which the data change is asymmetrical or uneven in shape.

ISO 9660 • The recommendations of the High Sierra group, adopted by the International Standards Organization to define the external characteristics of data on a CD-ROM disc (i.e. file structure – including 'header data' such as name, originator, copyright and date – directory structure, and the paths along which directories are arranged).

IV • *See* Interactive Video.

Joint Photographic Experts Group (JPEG) • The international consortium of hardware, software and publishing interests dedicated to developing international standards for the compression of still photographic images in digital systems.

Joystick • A popular input device for computer games (and some technical training applications), which employs a short rotating shaft, grasped in the user's hand, to direct the movement of the cursor on the screen.

JPEG • *See* Joint Photographic Experts Group.

KB • *See* Bits and bytes.

Kernel • The foundation (or lowest layer) of an operating system, at which hardware resources are allocated to the operating system's own processes, and computer programs which it controls.

Keyboard/keypad • Input devices which employ a number of discrete buttons or pressure-sensitive zones, typically labelled with alpha-numeric characters, brief descriptive labels (such as Enter or Return) and/or pictograms representing their dedicated functions.

Keywords • Words, phrases or abbreviations that have special significance within a given context (typically, to initiate a link in a hypertext system, effect cross-references in a database, or identify acceptable input in a free text search or test).

Kilobyte • *See* Bits and bytes.

Language • A medium of communication, in computing, between various hardware devices and software programs, and between users and machines. High-level languages resemble the vocabulary and syntax of human speech, low-level languages employ codes similar to the binary notation of the hardware itself.

LaserDisc • Reflective optical disc formats that combine analogue video with digital stereo sound in 12cm/4.75 inch 'singles' (with up to six minutes' video and 20 minutes' audio) or 20cm/8 inch and 30cm/12 inch discs which offer 20 minutes' and one hour's worth of linear video, with audio, respectively.

LaserVision • Philips' original videodisc format (supported by other manufacturers including Pioneer and Sony), which records analogue video and two analogue audio channels on a 30cm/12 inch reflective optical disc, in CAV or CLV formats.

Lead-in area/Lead-out area • The start and finish, respectively, of the data on a compact disc, on either side of the program area; the lead-in area (Track 0) contains the table of contents, the lead-out area (called Track $AA) identifies the end of the recording.

Learning points • Essential facts, lessons or insights which users should be expected to discover and understand, such as facts in a technical training programme or the features and benefits of a product in a marketing presentation.

Level A • The ADPCM audio quality level equivalent to that of a brand-new vinyl record, with 20kHz bandwidth, a sampling rate of 37.8kHz and eight bits per sample. Level A offers two stereo, or four mono channels, and occupies 50 per cent of the data channel in stereo, and 25 per cent in mono. A whole CD-I disc devoted to Level A audio could hold 2 hours and 24 minutes' worth of hi-fi stereo, or 4 hours and 48 minutes of mono.

Level B • The ADPCM audio quality level equivalent to that of FM radio, with 17kHz bandwidth, a sampling rate of 37.8kHz and four bits per sample. Level B offers four stereo, or eight mono channels, and occupies 25 per cent of the data channel in stereo, and 12.5 per cent in mono. A whole CD-I disc devoted to Level

A audio could hold 4 hours and 48 minutes' worth of mid-fi stereo, or 9 hours and 36 minutes of mono.

Level C • The ADPCM audio quality level equivalent to that of AM radio, with 8.5kHz bandwidth, a sampling rate of 18.9kHz and four bits per sample. Level C offers eight stereo, or 16 mono channels, and occupies 12.5 per cent of the data channel in stereo, and 6.25 per cent in mono. A whole CD-I disc devoted to Level A audio could hold 9 hours and 36 minutes' worth of low-fi stereo, or 19 hours and 12 minutes of mono.

Levels of interactivity • *See* Nebraska Scale.

Line control table • A set of data within the Display Control Program (DCP), containing up to eight separate instructions for the display of every line in a 525-line NTSC or 625-line PAL/SECAM video sequence.

Line standard • The technical standard that defines the number of parallel scans which comprise a single frame of analogue video: in normal resolution, NTSC employs 525 and PAL/SECAM, 625; current HDTV standards call for 1125 (MUSE) or 1250 (HD-MAC) lines per screen.

Linear • Presentations which typically run from start to finish, always in the same sequence and at the same pace, without interruption or variation.

Low-level • *See* Language.

Luminance • The radiance (or light emitted by) an image, expressed as the signal Y, which complements U and V, or chrominance.

Main Processing Unit (MPU) • CD-I's central processor, the operational core of the system which provides all the logical, arithmetical and control functions necessary to retreive, process and output data.

Master disc • The fragile glass model, cut in real time with a powerful laser beam which inscribes the pattern of digital data from the master tape into a spiral of shallow pits on the surface of the disc. A series of metal 'stampers' are taken from the glass model to impress the image of the master disc onto the blank plastic surface of the copies in a pressing facility. The glass disc can also be used as a check disc or, with care, as a working disc in applications which require few copies and minimal disc handling.

Master tape • In audio, video, LaserDisc and compact disc production, the high-quality magnetic tape on which the final edit of the complete recording is assembled for reproduction in the appropriate medium.

Mastering • The processes involved in converting data from a master tape to a master disc.

Matte • A specified area or region within an image or image plane, which can be encoded to appear transparent or opaque, to reveal or mask selected parts of the images

in other planes, when two or more separate images are superimposed on the same screen.

MB • *See* Bits and bytes.

Megabyte • *See* Bits and bytes.

Memory • Permanent or volatile storage of data in a computer-based system (e.g. RAM and ROM) or medium (e.g. magnetic disk or optical disc), usually measured in bytes.

Menu • A list of the choices or options available at any one time to users of a computer-based system. Menus typically employ icons or pictograms, short words, phrases or abbreviations. Pop-up or pull-down menus are normally represented on screen by one word or symbol, until selected by the user, when a larger range of options appears.

Menu-driven • A system which offers a finite choice of options from a single screen or a variety of pull-down menus; menu-driven systems are straightforward, easy to use but sometimes limited in scope.

Message Sector • A warning for users who put a CD-I disc in a CD-DA player, to lower the volume to accommodate the CD-DA system's more powerful audio output.

Micro-computer • The smallest of computers, a term now used interchangeably with personal or desktop computer.

Micro-processor • A chip or chipset which supports the central processing unit (CPU) of a computer, or computing facilities within devices of other kinds.

Mode 1 • The compact disc encoding format with special error detection and correction codes for sensitive data, employed by CD-ROM, DVI technology and CDTV. Mode 1 data must pass through the system's main processing unit before being relayed to the appropriate output channel.

Mode 2 • The compact disc encoding format employed by CD-ROM XA, Photo CD and CD-I, for data such as audio and video signals, which are not so sensitive to errors as computer signals. Mode 2, Form 1 contains the same error detection and correction codes as Mode 1, so data must pass through the system's main processing unit; Mode 2, Form 2 data can be relayed directly to the appropriate output channels. CD-I's program-related data are always recorded in Form 1, audio and video data in Form 2. Form 1 data are typically transferred at a rate of 150KB per second, Form 2 at 170.2KB per second.

Modem • MOdulator/DEModulator, a device to convert digital data for transmission over telephone lines.

Monitor • The computer's visual display unit (VDU); an output device for non-broadcast video (as opposed to a broadcast television receiver); or a screen which can display both digital computer images and analogue video pictures.

Mosaic • A special effect which enlarges an image (with some loss of quality), or reduces the visual quality of an image without changing its size (typically, to reduce the photographic quality of a 'natural' image to a patchwork of large monochrome blocks), effected in CD-I, by a combination of pixel hold and line hold functions.

Motion Picture Experts Group (MPEG) • The international consortium of hardware, software and publishing interests dedicated to developing international standards for the compression of moving video images in digital systems.

Mouse • A small input device, with a rotating ball on the underside and one or more buttons on top, hardwired to a computer-based system by a slender 'tail'. The user slides the mouse about (ideally, on a smooth, clean 'mouse pad') to direct a cursor around the screen, 'pointing' to select data or hotspots, and 'clicking' the appropriate button to effect choices or initiate action. The related trackerball, with both rollerball and buttons on top, works similarly from a stationery mounting.

MPEG • *See* Motion Picture Experts Group.

MS-DOS • Microsoft Disk Operating System, developed by Microsoft for IBM and compatible personal computers with Intel 16- and 32-bit micro-processors – and, thus, a *de facto* standard in computing (although since followed in the IBM environment by the more powerful PS/2 operating system).

Multimedia • The phrase used to describe hardware and software products and applications which combine a variety of audio-visual resources – usually including text, sound, graphics, and still and moving photographic images – which are generated, stored and processed in a wholly digital environment. Unlike interactive video (which typically combines an analogue videodisc with digital computer data, in a delivery system with at least two drives), multimedia typically employs one digital storage medium – usually, a large hard disk or some form of CD, which can hold both computer data and audio-visual material – and a delivery system which processes data of all kinds within a single desktop computer or CD player.

Multi-tasking • In computer-based systems, running two or more independent activities or processes concurrently.

Natural images • Photographic images from sources such as 35mm (or better) photo stock, film or video.

Nebraska Scale • Terms devised by the Nebraska Videodisc Design/Production Group to describe LaserDisc players, but commonly employed to indicate levels of interactivity in systems of all kinds. Level 0 describes non-interactive (i.e. linear) products; Level 1 provides controllable movement back and forth, quickly and slowly, and other features typical of a remotely-controlled TV or VCR; Level 2 describes a

system with a microprocessor which can run programs recorded on the disc or stored in an EPROM which slots into a drive built into the player itself. Level 3 describes a system which combines an audio/video player or drive with a discrete micro-computer to support full interactivity. Some commentators describe Level 4 as a system that (like CD-I) offers the functionality of Level 3 in one (small) box rather than two (large ones).

Network • Two or more discrete terminals or workstations, linked together or to a central facility, that can exchange and share data and resources.

Network File Manager (NFM) • An optional CD-I file manager, for extended systems, to control a number of CD-I players or OS-9 computers, in a network.

NFM • *See* Network File Manager.

Noise • The perceptible interference in an electronic circuit (typically, acquired during transmission or generated from errors); visible on the TV screen as 'snow' and audio in recordings as 'hiss'.

Non-linear quantization • A sampling technique which takes irregular, rather than uniform, steps to assign quantum values efficiently over the dynamic range (and exploit the fact that quantization errors are less obvious over large changes than small ones).

Non-Volatile RAM • The small (currently, 8KB) permanent memory in a CD-I base case player, which stores essential software programs, with some room for optional applications-specific data.

Non-Volatile RAM File Manager (NRFM) • The file manager within CD-RTOS which controls NVRAM and allows individual CD-I applications to write files to NVRAM.

NRFM • *See* Non-Volatile RAM File Manager.

NTSC • The colour standard established by the American National Television Standards Committee, now used generically to describe the (analogue) broadcast television and video standards employed in North America, Japan and their dependents; NTSC employs a 525-line screen, with 30 frames or 60 fields of data per second.

NVRAM • *See* Non-Volatile RAM.

Object-oriented • Describing systems in which all processes and data are represented by discrete entities, which typically employ high-level software to encompass a complex data structure within a single package, and usually present this to users through a brief, descriptive text label or name and, often, pictogram.

Off-line • Devices and services that are either not connected to a central source or system or, if connected, not active: an off-line database or video editing suite is typically self-contained, with limited facilities and resources.

OMDR • Optical Memory Disc Recorders (i.e. recordable LaserDisc systems).

On-line • Devices or services that are in active communication with a central source or system: an on-line database typically draws on a large central resource which is frequently updated, an on-line video editing suite deploys a battery of high-quality equipment for mixing and special effects.
Operating system • Sets of software programs which define how data are brought into a computer, processed, and sent to appropriate output devices, and how the computer communicates with peripherals under its control and/or other systems in a network.
Optical disc • A storage medium in which digital data are typically written (recorded) as a series of shallow pits in a long spiral track, cut into the surface of a thin glass or plastic platter by a strong laser beam. This glass master provides the model for metal stampers which are used to impress this pattern on blank plastic discs. The disc is typically read by a low-powered laser which passes a pattern of beams to a photodiode which translates these to the signals required by delivery system's processor and output devices. Reflective optical discs such as LaserDiscs and compact discs cover the impressed surface with a thin metallic film that bounces the laser beam off its surface. Transmissive systems employ translucent discs, and pass the beam through the disc.
Orange Book • The functional specification employed by recordable compact disc formats such as Photo CD.
OS-9 • An operating system originally written for Motorola's 6809 micro-processor in the late seventies, adapted to the high-performance 68000 in 1983, and used as the basis of CD-I's own CD-RTOS.
Output • Data generated or processed for display on a screen, relay through speakers or headphones, transmission to another system or network, encoding onto a magnetic disk or optical disc, or printing on paper, photographic film or other media.
Overscan • The technique, used in consumer products, of extending the deflection of the electron beam in a cathode ray tube (CRT) beyond the physical boundaries of the screen, to ensure that images will always fill the display area; conversely, professional TV and video systems often employ underscanning to ensure that the complete image is always visible within the display area.
P Channel • The first of CD-DA's eight sub-code channels (P to W), which carries the 'music flag' to mark the end of each individual track.
Padding • Empty sectors (i.e. those which the binary values in all 2324 bytes are set to 0), interleaved amongst sectors of other data, to facilitate the synchronization of data flowing through the system.
PAL • Phase Alternate/Alternating/Alternation Line, the television and video colour standard developed in West Germany and now used generically to describe the

(analogue) broadcast television and video standards employed in the UK, most of Europe, Africa, Australasia and South America. PAL employs a 625-line screen, with 25 frames or 50 fields of data per second.

Palette • The maximum range of colours available for use at any one time in a computer graphics format or software package.

Panning • To distribute a mono audio signal between the left and right channels of an output device equipped for stereo sound.

Parent directory • The directory immediately above a sub-directory in a hierarchical path table.

Partial-screen update • An encoding technique which only refreshes the data in a designated part of the screen (typically, within a larger, static image), for example to limit movement to the eyes and mouth of a talking head.

Path • The route through an interactive presentation (often with diverse branches and connections between paths); and the route to specific data in a computer system, through a hierarchical structure of directories, sub-directories and files.

Path table • The record in CD-I's disc label which describes the hierarchical arrangement of all the directories and files on the disc.

PC • *See* Personal Computer.

PCM • *See* Pulse Code Modulation.

Peripherals • Hardware devices (such as keyboards or printers) which are physically separate from a computer, but integral to its operations, and under its control.

Personal Computer (PC) • A micro-computer that is designed for the use of one person at a time. It may be networked to other systems but, unlike a terminal, can operate entirely on its own. Unlike an integrated workstation, the PC usually employs a discrete monitor and peripherals such as keyboard and mouse. The term 'PC' is particularly associated with IBM and compatible desktop computers.

Photo CD • A high-quality photographic storage medium developed by Kodak in line with the specifications for recordable compact discs defined by the *Orange Book*. One Photo CD disc can store up to 100 digitally-encoded 35mm photos at resolutions up to four times greater than those of HDTV. These images can be displayed on ordinary televisions, processed and printed like ordinary negatives, and imported into desktop publishing and other computer-based design and presentation systems.

Photodiode • *See* Optical disc.

Pixel • 'Picture element', the minute point of light and colour which is the smallest discrete element in a video or computer image. Digital systems measure image quality in pixels per screen: the more pixels, the higher the definition or resolution of the image.

Pixel hold • A technique to effect mosaics or granulation, in which the size of an image remains stable while its visual quality is reduced: the values of one pixel are held over a given number of pixel positions (horizontally and vertically), replacing the values of the individual pixels which previously appeared there. Pixel hold can be used with any CD-I graphic format.

Pixel pair • The technique of putting two pixels together, in one byte of data, and treating these as one subsequently. DYUV encoding assign a Y value to each pixel, but a UV value to each pair; pixel pairs effect double resolution in CLUT 4 and RLE 3.

Pixel repeat • A technique to increase the size of an image or detail, by repeating the values of each pixel over a given number of pixel positions. The magnified image is less sharp than the original, since a finite amount of data is spread over a greater area. Pixel repeat can only be used with RGB 5:5:5 and CLUT encoding (i.e. not with DYUV photographic images).

Play Control Block (PCB) • The data structure within the Play System Call which determines what data are needed for the current or next real-time record, and de-interleaves real-time data, to send audio, video and program-related sectors to the appropriate processors or memory banks.

Play Control List (PCL) • Records supplied to the Play Control Block for each type of datum (audio, video, program-related), to describe the control and status fields, point to the appropriate buffer for the data, and to the next PCL entry.

Play System Call • The routine for retrieving real-time records which selects individual sectors by their file number, data type (audio, video or program-related) and channel number (i.e. 0 to 15 for audio, 0 to 31 for other data).

POI (Point-of-information) • *See* Point-of-sale.

Point-and-click • *See* Mouse.

Point-of-sale (POS), Point-of-purchase (POP), Point-of-Information (POI) • Displays that provide information, advice or promotional material, usually to the public in a commercial environment such as department store or shopping mall, or recreational site, exhibition or museum. POS is preferred in the UK, and POP in the US, for systems which promote or even sell products or services; POI tends to distinguish systems that primarily provide information or instruction without a sales message (but which may include some advertising, typically to subsidize the information service).

Pointing device or pointer • A tool which effects communication between the user and the system by locating data and hotspots on the screen, typically through the agency of a cursor which the user controls with a mouse, joystick or similar device.

Port • A socket or contact point (usually conforming to an universal technical standard such as RS-232 or SCSI) which effects connections between a computer's central processor and peripheral devices.

POS (Point-of-sale) • *See* Point-of-sale.

Post-production • The many and various degrees of preparation, processing, editing, assembly and packaging that follow the actual creation of audio-visual material in a film, video or multimedia presentation.

Pre-mastering • Technical activities required to process the final edited version of an interactive video or multimedia presentation for transfer to optical disc ('mastering').

Pre-production • The stages of research, design and preparation which precede the actual creation of audio-visual material.

Pressing plant • An optical disc production facility that typically offers a range of related services, including pre-mastering and mastering. Discs are replicated by stamping a metal mould (copied from the master disc) onto a blank plastic platter.

Process • A task or activity within a computer-based system.

Professional • Effectively synonymous with corporate or industrial, to describe audio-visual and computer products for commercial rather than consumer markets.

Program and programme • 'Program' describes computer software (specifically, the instructions which control hardware systems or software applications); 'programme' more broadly embraces all the elements in an audio-visual or multimedia presentation (which may include software programs as well as audio, video, text, graphics and other data).

Program area • The main body of a compact disc (between the lead-in and lead-out areas), containing up to 99 tracks.

Program-related data • Run-time text, indexes, hotspots, navigation and other CD-I data which are not specifically audio, video or program code (but which are always recorded in Mode 2, Form 1).

Programming • The creation of a set of commands or instructions for a computer-based system, typically by writing code in a dedicated computer language.

PS/2 (Personal System/2) • *See* MS-DOS.

Pull-down menu • *See* Menu.

Pulse Code Modulation (PCM) • A technique for converting analogue signals to digital values, by sampling the analogue signal (at a rate at least twice that of the maximum signal frequency) and assigning each sample a binary value which can be transmitted as a series of pulses in an electronic communications system.

Pulse code • A signal recorded or transmitted at regular intervals to communicate information or synchronize data transfer.

Q Channel • The second of CD-DA's eight sub-code channels, which distinguishes audio and other data, advises if pre-emphasis is applied and whether digital copying is permitted, provides a table of contents, running times for each track and the disc as a whole, and an error detection routine called cyclic redundancy check (CRC).

QHY • *See* Quantized HY.

Quantize • To represent data strictly within an appropriate set of discrete values using quantum numbers (i.e. integers – whole numbers – or half-integers that express a quantity of energy in proportion to the frequency of radiation).

Quantized HY (QHY) • A variation on DYUV (which only supports normal resolution), which enhances the luminance signal to the level which high-resolution displays demand.

RAM • *See* Random Access Memory.

Random Access • The facility to retrieve data (rapidly and accurately) from any part of a recording.

Random Access Memory (RAM) • A read-write memory device comprising myriad discrete cells with a storage capacity of one bit each. Every cell is individually addressable and capable, therefore, of supporting random access to the data stored there. Static RAM devices hold data until they are overwritten or the power is removed (e.g. if the power fails while work is in progress, any data not yet written to RAM – 'saved' or 'stored' – will be lost; data already written should be preserved). Dynamic RAM (DRAM), with different storage techniques, offer greater cell density and lower power consumption, but are generally slower than static RAM devices.

Random Block File Manager (RBF) • An optional CD-I file manager, for extended systems, to control files on mass volume storage devices such magnetic hard or floppy disk or RAM disk drives.

Read • To retrieve, process and display recorded (written) information. A read-only medium or device – such as a conventional compact disc – is one which cannot record (write) new data; a read-only disc is usually pre-recorded at a professional facility and issued as an immutable permanent record.

Read-Only Memory (ROM) • A read-only memory device that, once written, typically holds data immutably thereafter. The contents of the memory are installed in a mask ROM device when it is made; data can be supplied separately to a programmable ROM (PROM) after manufacture, through special programming techniques: both are typically built into a computer or drive. An Erasable PROM (EPROM) or Electrically Erasable ROM (EEROM) can be frequently re-programmed, or erased and overwritten (for example, to run small programs in a system which

employs its own micro-processor rather than a separate computer, such as an interactive video system at Level 2 on the Nebraska Scale).

Read/write • Media and devices that can both record (write) and recover (read) data (and, with associated memory, store this information permanently or temporarily).

Real time • The fourth dimension as we normally experience it and, thus, data or systems which supply information or services immediately they are required (rather than, say, in artificially elapsed time, with data already processed for delivery, or after undue delays); written as an adjective, as real-time.

Real-Time Control Area (RTCA) • A location at the start of every real-time file which stores commands to direct the use of real-time records, loading and unloading of audio and video data, audio output, and the handling of drawmaps.

Real-Time Record (RTR) • The smallest unit of real-time data on a CD-I disc, containing audio, video or program-related data.

Real-Time Record Interpreter (RTRI) • A multi-tasking interpreter, capable of handling many tasks in parallel, which handles CD-I's real-time files.

Record-keeping • Software management facilities which, for example, monitor a student's progress through a course, or maintain a record of players' scores in a game.

Recorded area • The total length of data on a compact disc, comprising the lead-in area, program area and lead-out area.

Rectangular update • A partial-screen update where the region within which the data change comprises a symmetrical shape with four right angles.

Red Book • The universal functional specification for CD-DA.

Reflective optical disc • Optical disc formats in which the digitally-encoded surface of the disc is covered with a thin membrane of reflective metal foil. The disc is read by a low-powered laser beam whose light bounces off the patterned surface of the disc through a network of prisms and mirrors to a photodiode which decodes variations in the reflected light into audio-visual and other information for the various components of the delivery system.

Refresh • To supply new data to a display or process, or replenish the power supply to a hardware device.

Region • A defined area within the screen, within which drawmaps, mattes or other graphic functions can be deployed.

Replication • The reproduction of optical discs, usually at a professional pressing facility. (The term 'duplication' tends to describe the reproduction of audio and video tape.)

Resolution • Visual or picture quality, usually measured in lines or pixels per screen. CD-I will support normal resolution at 384x240 (NTSC) or 384x280 (PAL/SECAM);

double resolution at 768x240 (NTSC) or 768x280 (PAL/SECAM); and high resolution at 768x480 (NTSC) or 768x560 (PAL/SECAM).
RFM • *See* Random Block File Manager.
RGB (Red Green Blue) • The standard encoding method for full-colour images in digital display systems, typically with eight bits of data for every level of red, green and blue – that is, 2^8 or 256 separate levels for each, or 16 777 216 altogether. This is effectively RGB 8:8:8: CD-I employs the more economical RGB 5:5:5, which encodes only the most significant five bits per level (providing 2^5 or 32 colours apiece), which effects a compression ratio of 3:2 over standard RGB at normal resolution, with no significant loss of quality.
RLE • *See* Run-Length Encoding.
Rollerball • *See* Mouse.
ROM • *See* Read-Only Memory.
Root directory • The first (or 'highest level') directory in the hierarchical collection of data on, for example, a CD-I disc or hard disk.
Rostrum camera • A special camera which captures conventional artwork on film or tape, either by holding on a still frame or detail, or by moving smoothly over a large or detailed image.
RTCA • *See* Real-Time Control Area.
RTR • *See* Real-Time Record.
RTRI • *See* Real-Time Record Interpreter.
Run-Length Encoding (RLE) • A CD-I graphic format, particularly appropriate for animation, which encodes the colour of the first pixel in a line, and then records the length (in pixels) for which this colour runs, until another colour appears. RLE 7 offers 128 colours in normal resolution (i.e. seven bits of data, or 2^7, for every level of RGB); RLE 3 supports eight colours in double resolution (i.e. three bits of data, or 2^3, for every level of RGB).
Safe area • The area in the centre of a screen in which data are always displayed, despite the effect of overscan, convex screens, and differences between products from competing manufacturers. CD-I defines safe areas of 320x210 (NTSC) or 320x250 (PAL/SECAM) at normal resolution, 640x210 (NTSC) or 640x250 (PAL/SECAM) at double resolution and 640x420 (NTSC) or 640x500 (PAL/SECAM) at high resolution.
Saturated colours • Intense colours which often appear to 'bleed' into adjacent colours, or glare unpleasantly on the screen.
Scan • The process of reading, transmitting and/or outputting data by collecting signals in an orderly pattern, usually over closely-packed parallel lines. Analogue television

and video displays typically employ a pattern of two, interlaced scans (of one field apiece) for every frame of visual data. Scanners capture (i.e. record) text or graphics, usually for conversion from an analogue medium to digital data storage. The 'scan' feature of a video player typically allows viewers to see something of the images as they pass rapidly forward or backward, to identify the point at which to stop.

SCF • *See* Sequential Character File Manager.

Scroll • To move gradually down or across a display that is longer or wider than a single computer or video screen.

SCSI • *See* Standard Computer System Interface.

Search • To seek, find and retrieve specific data.

SECAM • Séquential couleur à mémoire, the colour standard developed in France, now used generically to describe the (analogue) broadcast television and video standards employed there, in eastern Europe, the USSR, and parts of the Middle East and Africa; SECAM employs a 625-line screen, with 25 frames or 50 fields of data per second.

Sector • The smallest discrete unit of addressable information in CD-ROM, CD-ROM XA or CD-I disc (equivalent to CD-DA's frame), comprising 2352 bytes of data, including a header field and, optionally, a sub-header and EDC/ECC error protection codes.

Seek time • The real time required to find data on the disc, position the reading head within the drive or player, and begin data transfer.

Sequential Character File Manager (SCF) • An optional CD-I file manager, for extended systems, to control optional peripheral devices such as a printer or modem.

Software • Data such as computer programs, audio-visual and multimedia presentations, which control hardware systems and devices (systems software), and provide information and services to their users (applications software); also, by extension, the consumables on which these data are stored (e.g. magnetic disks or optical discs).

Sound group • The 18 discrete units within every sector of CD-I audio data, comprising 128 bytes each (or 2304 bytes altogether). Each devotes 16 bytes to sound parameters, and the remaining 112 bytes to audio data.

Soundmap • A block of memory allocated by the User Communications Manager (UCM) to store audio data (including special effects and music) temporarily in one of CD-I's two memory banks.

Sprites • Small images or characters (such as the alien invaders which stream through many popular computer games) which can easily be manipulated on the screen during the course of a presentation.

Stamper • *See* Master disc.
Stand-alone • Devices or systems which can function on their own, without depending on a central facility for power, data or other services.
Standard Computer System Interface (SCSI) • 'Scuzzy' – a standard interface to facilitate data transfer to and from bulk storage devices and high capacity hard disk drives.
Still frame • A single, static image designed and produced to appear motionless on the screen.
Stock • Blank, unrecorded photographic film or magnetic tape for audio-visual production.
Storyboard • The series of pictures on paper which sketches the structure and content of a film or video production; in IV, these are usually detailed visual plans for the production work to follow.
Stylus • *See* Head.
Sub-channel • *See* Sub-code channel.
Sub-code channel • Eight sub-channels (P to W) which run parallel to the main data channel in a compact disc, and which can hold control and display data as well as some text and graphics; see also P Channel and Q Channel.
Sub-directory • *See* Directory.
Sub-header • The 12 bytes of data that follow the header at the start of a CD-I sector to record the data type (e.g. audio, video or program-related), coding information (e.g. Level A audio or CLUT 7 video), file number for interleaved files, channel number (i.e. 0 to 15 for audio, 0 to 31 for other data), and flags to indicate Form 1 Form 2, real-time or non-real-time files, end-of-file and end-of-record bits and time-coded trigger bits.
Sub-mode byte • Data which describe the global (e.g. common) characteristics of all the data in any one sector.
Sub-screens • One or more horizontal panels within a larger screen that can employ different graphics formats and/or resolutions (for example, to display captions at double resolution on an image in normal resolution).
Surrogate travel • Various techniques which simulate journeys through real, hypothetical or imaginary environments, through the use of moving film or video, minutely graduated still shots and/or computer graphics. In training or crisis management, surrogate travel provides a visual record of a place which may be remote, dangerous, secure or otherwise physically inaccessible. In training or entertainment, it may also create a typical or fantastical environment which users can study and explore.

Synchronization • The control of processes (such as the delivery of data to output devices) which ensures that complementary activities are initiated, performed and completed in the right order and at the appropriate pace.

System text • Messages generated by the operating system of a CD-ROM, CD-ROM XA or CD-I system without use of a dedicated text processing program.

Teletext • Digitally-encoded data (typically, text databases or captions, perhaps with simple graphics) which are transmitted in the spare channel capacity of a broadcast television signal for display on a suitably-equipped TV. National teletext services include Britain's Ceefax and Oracle, France's Antiope and Didon, Germany's Bildschirmzeitung and Videotext, America's Closed Captioning and Canada's Telidon.

Terminal • An input and/or output device or system that is typically dependent on a central processor at a discrete, remote location.

Terminator Record • *See* Disc label.

Time code • A signal or record which locates data chronologically in relation to the beginning of a recording (typically, in hours, minutes, seconds and sectors or frames).

Touchscreen • A screen or membrane for a video or computer monitor that typically employs X-Y co-ordinates to interpret pressure in designated locations (i.e. hotspots) as input to initiate actions or responses.

Track • The path or channel along which data are recorded in a computer or audio-visual tape, magnetic disk or optical disc; also, a set of related or contiguous data (such as one song on a CD-DA disc, or one application on a CD-I disc). A CD can hold from one to 99 tracks, each comprising from 300 sectors (i.e. about four seconds' worth) to the total recordable surface of the disc. A CD-I track can contain any combination of audio, video and program-related data.

Tracker ball • *See* Mouse.

Transparency • In visual displays, the facility to expose selected parts of a background image by rendering complementary portions of the foreground image either wholly or partially translucent. In artwork, a positive colour image on photographic film. Also, the degree to which complex processes are accomplished by a delivery system or technology without attracting undue attention from users.

Transparency bit • A dedicated bit which controls the overlay of the (optional) translucent portions of the cursor plane and RGB 5:5:5 images.

Trigger • A bit (recorded in the sub-mode byte of the sub-header) that can be used as a reference point to synchronize data or initiate activities.

U • *See* Chrominance.

UCM • *See* User Communications Manager.

UCM User Interface • That portion of the UCM that supports X-Y pointing devices such as the thumbstick controller, and optional devices such as a keyboard or mouse.
Upgrade • To enhance hardware or software already in use by replacing or adding equipment, programs or features to meet new or improved standards of performance.
User Communications Manager (UCM) • The file manager within CD-RTOS that controls audio-visual devices, directs CD-I audio to the ADPCM decoder, manages the cursor, and controls input devices such as the hand-held controller and keyboard.
User data • Information for use by the audience, rather than the delivery system itself.
User interface • Devices and techniques dedicated specifically to communication between people and machines.
UVLO (Low Resolution U and V) • A compression system that reduces the amount of data in a sequence of moving video and, thus, allows the video window to occupy a larger proportion of the CD-I screen.
V • *See* Chrominance.
VCR • Video Cassette Recorder.
VDU • *See* Monitor.
Vertical interpolation (UVLO+) • A CD-I encoding technique that can double the size of the video window (while reducing visual quality) by supplying the same data to both fields of the interlaced analogue video signal.
VGA • Describing graphics which employ the standards set by the Visual Graphics Adaptor card introduced with IBM PS/2 personal computers, which supports resolution at 640x480 with a choice of 256 colours from a palette of 262 144.
VHS (Video Home System) • The 12.5cm/0.5 inch videotape format developed by JVC (and supported by many others) for consumer and corporate markets.
Videodisc • A format that records still and/or moving pictures, with or without sound, on a magnetic, electronic or optical platter.
Videowall/vidiwall • A bank of display (usually, video) screens drawing images from a central source (typically, one or more videodisc players) under the control of a computer or processor, to create a variety of patterns, from a different image on each screen to a single image spread across all the screens.
Visual Display Unit (VDU) • *See* Monitor.
Voice-over • Disembodied speech which accompanies discrete visual images, without showing (and even without identifying) the speaker.
Volatile • Temporary or subject to change, as in volatile memory (which is frequently written, erased and rewritten during the course of a program, and erased altogether

when the power supply ceases), or volatile data (which may be amended or upgraded more often than other information in the same programme or data set).

WIMP (Window, Icon, Mouse, Pointer) • The characteristic features of a system employing a graphical user interface (GUI).

Window • The effect or feature in which data from various sources can be displayed simultaneously in different parts of the screen, typically in rectangular boxes which can be designed, scaled, moved and manipulated in various ways, by the designer and, sometimes, by the user as well.

Wipe • A special effect in which one picture replaces another by moving across the screen, in any direction, to cover the former image.

Workstation • An integrated system, typically comprising a computer, one or more drives for magnetic disks or optical discs of various formats, a screen and input devices such as a keyboard and mouse.

WORM • *See* Write Once, Read Many.

Write • To record data which can subsequently be read and, sometimes, erased or overwritten.

Write Once, Read Many (WORM) • Media on which one set of data can be recorded, but not erased or over-written subsequently (such as recordable CD-ROM or Photo CD discs).

X-Y device • Any input device which employs the horizontal (X) and vertical (Y) co-ordinates of a screen (for example, to move a cursor, select options or input data in specific locations).

Y • *See* Luminance.

Yellow Book • The universal functional specification for CD-ROM and, with extensions, for CD-ROM XA.

Appendix 4

Multimedia timeline

This appendix lists key events and significant trends in the years between the patenting of Phonovision in 1926 and the release of CD–I in 1991/92.

1926 • In the UK, John Logie Baird's Television Ltd file the first patent for a videodisc system, Phonovision

1928 • In the UK, Television Ltd file the first patent for a dedicated videodisc player

1935 • In the UK, Major Radiovision launch a version of the Phonovision disc for use on conventional gramophones

1936 • In the UK, the British Broadcasting Corporation (BBC) launch EMI's 405-line electronic television

1937 • In the UK, production ceases on Baird's mechanical television, Televisor

1956 • In the US, Ampex release the first successful videotape system, the two-inch Quad format for broadcast television

1958 • In the US, D. Paul Gregg (then working for Westex) develops the reflective optical format which he calls 'videodisk'

1962 • In the US, SRI demonstrate a version of Gregg's invention which uses photographic film rather than a rigid disc

1966 • In Japan, Sony release the mechanical videodisc system, Videomat, for slow-motion replays in broadcast television

1970 • In Germany and the UK, AEG-Telefunken and Decca release the Teldec mechanical videodisc system

1971 • In the US, MCA DiscoVision demonstrate a prototype of the reflective optical videodisc system later known as LaserVision; at least three dozen videodisc systems of various kinds are demonstrated by European, American and Japanese companies over the next 20 years

1972 • In the Netherlands and the US, Philips demonstrate Video Long Play (VLP), the immediate precursor of LaserVision

1975 • In the US, RCA demonstrate the SelectaVision capacitive videodisc system

• In France, Thomson CSF-Brandt demonstrate a transmissive optical videodisc system

1976 • In the Netherlands, Philips demonstrate LaserVision

1976 • In Japan, Japanese Victor Company (JVC) demonstrate the Video High Density (VHD) capacitive videodisc system

1977 • Pioneer launch their first reflective optical videodisc player

1978 • In the US, LaserVision is launched on the consumer market just before Christmas

1979 • In the US, DiscoVision Associates (DVA) are established as a joint venture between MCA and IBM to develop and promote laser videodisc technologies

• In the US, General Motors jump-start the IV market with an order for 12 000 industrial-quality Pioneer LaserDisc players for their nationwide dealer network

• In the US, the Society for Applied Learning Technology (SALT) hold their first conference on Interactive Videodisc in Education and Training, the Nebraska Videodisc/Design Production Group hold their first symposium, and Meckler Communications hold their first annual Videodisc/Optical Disk Conference

1980 • In the US, Pioneer launch their first consumer LaserDisc players

1981 • In Japan, Pioneer launch their first consumer LaserDisc players

• In the UK, Sony introduce the tape-based Responder interactive video system

• In the UK, EPIC Industrial Communications hold their first annual Interactive Technology Briefing

1982 • In the UK, Philips launch LaserVision on the consumer market

• In the UK, Pioneer supports the first three bespoke disc-based IV projects with industrial-quality PR7820 NTSC players imported from the US

• In the US, LaserVision releases for the consumer market include Vidmax's interactive mystery game, *Murder, Anyone?*

1983

January

• Two American newsletters, *Optical Memory Newsletter* and *Video Marketing Research*, proclaim 1983 'The Year of the Disc'

• In the US, JVC, General Electric, Matsushita and Thorn EMI dissolve their partnership to promote VHD before the format is released

- Pioneer announce plans for a 20cm/8 inch videodisc 'single'
- Matsushita demonstrate a prototype Optical Memory Disc Recorder (OMDR)

March
- In the US, Sega Industries demonstrates the prototype of an arcade game with images from a laser videodisc

April
- In Japan, JVC launch the VHD videodisc format on the consumer market

May
- In Germany, Pioneer launch their first LaserDisc players

July
- In the US, the first videodisc-based arcade game, *Dragon's Lair*, sparks a nationwide craze (which proves to be a nine days' wonder)

August
- In the US, RCA demonstrate the SJT-400 CED player with random-access facilities to support interactive video

September
- The Nebraska Videodisc/Design Production Group introduce a videodisc awards competition to their annual symposium

October
- In the UK, RCA and Hitachi launch CED on the consumer market

November
- In the UK, Thorn EMI and JVC announce the launch of industrial-quality VHD players into the professional market
- In Japan, laser videodisc-based systems for the sing-along entertainment craze, karaoke, are one of the hits of the Japan Electronics Show

December
- Philips and Sony formally agree format and manufacturing standards for CD-DA
- In Australia, laser videodiscs are launched on the consumer market

1984

January
- In the UK, Thorn EMI introduce the VHD format to the professional market
- In the UK, Philips launch the VP-835 industrial-quality PAL LaserVision player

February
- In the US, Panasonic demonstrate an OMDR with full-motion video and audio

April
- RCA announce the phased withdrawal of support for the CED format
- In the UK, Pioneer enter the consumer laser videodisc market
- Laser videodisc pressing facilities begin to offer while-you-wait check discs, and same-day turnaround on high priority disc pressing

June
- In the US, Pioneer demonstrate 20cm/8 inch laser videodiscs, and announce a Still with Sound and Data (SWSD) format to encode audio or digital data to accompany still video frames on a dedicated LaserDisc

September • In the UK, the National Interactive Video Centre (NIVC) is established, with support from the Department of Trade and Industry (DTI), Philips and Thorn EMI

October • In Japan, Pioneer, Sony and TEAC launch combi-players which handle both laser videodiscs and compact audio discs

November • In the UK, the first Philips Awards for interactive video are judged and presented during the Fourth Annual EPIC Interactive Technology Briefing

• In West Germany, Bell and Howell introduce VHD to industrial markets

1985

January • In the US, Pioneer introduce the CLD-900 combi-player

February • In the UK, Thorn EMI and Taitel Electronics introduce a VHD jukebox

April • In the US, McDonnell Douglas Electronics announce plans for a real-estate information system to use their LaserFilm videodisc format

• Sony introduce the VIEW LaserDisc-based delivery system

May • Digital Equipment Corporation (DEC) introduce the first fully-integrated computer system with CD-ROM

• In the US, LaserVideo demonstrate a proprietary interface device to link laser videodisc and compact discs in a single delivery system

July • Grolier announce an electronic version of their *Academic American Encyclopedia* on CD-ROM for the consumer market

• In the UK, Thorn EMI split production at their disc pressing plant between VHD and CD

August • Matsushita, NV Philips and Sony announce plans to develop a compact disc video format, with support from Warner Records and PolyGram

• In Germany, Bell and Howell call off their promotion of VHD in the professional market

September • In the UK, the British Interactive Video Association (BIVA) hold their inaugural meeting, under the aegis of the NIVC

• In Germany, NV Philips re-direct their marketing effort for LaserVision from the consumer to the professional market

• JVC introduce VHD to the French and, with National Education Corporation (NEC), American professional markets

October • NV Philips and Du Pont Company undertake a joint venture to make and distribute optical disc products as Philips Du Pont Optical (PDO)

	• In the US, Sony buy CBS's half-share in their joint venture, Digital Audio Disc Corporation (DADC)
November	• The British Interactive Video Association (BIVA) sponsors the Fifth Annual UK Interactive Technology Briefing with its organizers, EPIC Industrial Communications

1986

January	• In the US, Pioneer establish the LaserDisc Corporation of America to distribute LaserDisc and other software
March	• Philips and Sony announce preliminary specifications for CD-I
	• In the US, Microsoft Corporation sponsor their first annual International Conference on CD-ROM, in Seattle, Washington
	• In Japan, Pioneer introduce their first LaserDisc-based jukebox
	• In the US, Cable Video Jukebox uses a videodisc jukebox to offer a form of interactive television to cable TV subscribers in Miami
April	• Philips propose preliminary specifications for moving video on compact disc in the CD-V format
	• In the US, Philips and PolyGram form Philips Interactive Media of America (PIMA), to co-ordinate the development of CD-I software
June	• Philips and Sony issue the first provisional functional specification for CD-I
	• The High Sierra group complete their draft technical standard for CD-ROM
	• Sansui make players for McDonnell Douglas's LaserFilm videodisc format
	• RCA press their last CED videodisc
August	• Pioneer begin mass production of compact discs and CD-DA players
	• In the US, LaserDisc announce a 'compact LaserDisc' format which puts a digital audio track on a standard 30cm/12 inch LaserDisc
	• In Japan, JVC demonstrate 3D on a VHD videodisc system
September	• Microsoft announces extensions which allow equipment with the MS-DOS operating system to support CD-ROM drives and software
October	• Philips and PolyGram form European Interactive Media to co-ordinate the development of CD-I software in European markets
	• Panasonic introduce new recorders and players for their OMDR format, and Teac launch another recordable 30cm/12 inch format; neither is compatible with the other, nor with standard LaserDiscs

- In the US, Visage demonstrate desktop video with digital capture and manipulation of video and audio, and integration of a LaserDisc player

November
- The BBC release the Domesday Project, with Advanced Interactive Video (AIV) delivery system, using Philips' LaserVision-Read Only Memory format (LV-ROM)
- Philips and R.R. Donnelly & Sons form the OptImage Interactive Services Company, a production service for CD-I developers
- CD-ROM manufacturers including Philips and Sony agree a format for a 12cm/4.75 inch optical read-only memory disc (OROM)

December
- The British Interactive Video Association (BIVA) take over the EPIC Interactive Technology Briefing, which becomes the Interactive '86 Conference and Exhibition

1987

April
- Pioneer begin mass production of the Compact Disc-Video (CD-V) format
- Panasonic introduce a high-resolution monochrome OMDR for still and moving footage on a 30cm/12 inch laser videodisc

June
- NV Philips announce the first full functional specification for CD-I

August
- In the US, the Interactive Video Industry Association (IVIA) hold their inaugural meeting in Washington DC
- JVC announce enhancements including high-definition to the VHD format

October
- In Italy and Spain, Pioneer introduce their LaserDisc jukebox

December
- In the UK, the Philips Awards become the BIVA Awards

1988

January
- In Japan, PolyGram, Yamaha and Pony Canyon form Japan Interactive Media, a joint venture to make and distribute CD-I hardware and software
- In the US, Warner New Media launch Compact Disc Plus Graphics (CD+G)
- In the US, Pioneer and Sony introduce combi-players
- In the US, Pioneer introduce a changer which accommodates up to 72 double-sided 30cm/12 inch LaserDiscs, and SOCS Research introduce a changer which handles up to 240 double-sided CDs in CD-DA, CD-ROM or SOCS's own Compact Video Disc (CVD) format

February
- In Japan, Pioneer introduce the CLD-99S combi-player, with 8-bit digital memory and 1MB dynamic RAM to support real-time storage of video images within the player itself

March
- Philips acquire a worldwide licence under all current and future patents held by DiscoVision Associates (DVA)
- In Japan, Pioneer introduce the LD-W1, which can read either side of a LaserDisc without turning the disc in the player
- In Japan, Matsushita, Panasonic, Sanyo and Sharp shift from the VHD videodisc format to laser videodiscs
- In the US, EECO introduce a board to decode still-frame audio and digital data from laser videodiscs
- In the US, Optical Data Corporation release *The Voyager Gallery*, the first computer-enhanced discs for the consumer and educational market, with still and moving footage of planets and their satellites
- Teac introduce a non-standard, monochome recordable videodisc recorder and player
- The LaserVision Association of the Pacific (including Philips, Pioneer, and Sony) agree to use the abbreviations LD for laser optical videodisc, LDP for laser videodisc players, and CD Video LD for laser discs with analogue video and digital audio

April
- In the US, Pioneer establish Pioneer Laser Entertainment to promote karaoke systems in American markets
- In the US, New Media Graphics introduce the Video Windows overlay board, to process analogue video in digital form for a PC with EGA graphics
- In the UK, Applied Learning, IBM and Sony license VideoLogic's MIC System Software

May
- Panasonic demonstrate a colour OMDR for 30cm/12 inch laser videodiscs
- In the US, Pioneer announce the CLD-3030 combi-player which supports freeze frames from a CLV disc, still frame audio, and special effects
- In the US, Sony release their first combi-player for the consumer market, the MDP-200

June
- In the US, Capitol Disc install a CD-I authoring studio in Washington DC

- In the US, Warner New Media introduce CD+MIDI, which enhances the CD+G format by adding musical instrument digital interface (MIDI) to the combination of digital audio and graphics

July
- In the US, Optical Disc Corporation win an Emmy Award for Outstanding Achievement in Engineering Development for their Recordable Laser Videodisc (RLV) system

August
- In the US, Insite Peripherals file four patent applications for the 9cm/3.5 inch 'floptical disc', which combines magnetic and optical storage techniques
- In the US, the Media Lab at the Massachusetts Institute of Technology (MIT) demonstrate a video compression technique that supports one hour of video on a compact disc, using an Apple Macintosh II computer

September
- PolyGram officially launch the Compact Disc Video (CDV) format
- Teac introduce a lower-cost, double-sided laser videodisc recorder

October
- In the US, PIMA announce that the projected consumer launch of CD-I has slipped to the end of 1989, but predict $200 players and high-resolution full-motion, full-screen video by 1992
- In the UK, Nimbus Records announce a new high-density compact disc format with up to four times the storage capacity of current CDs

November
- NV Philips and Sony publish the *Green Book*, CD-I's functional specification, for release only to full licensees
- In the UK, Philips and Sony demonstrate prototypes of HDTV-compatible videodisc players
- In the US, Philips and Sony announce a 9cm/3.5 inch mini-CD with 200MB storage capacity
- In Japan, Taiyo Yuden launch write-once recordable CDs
- In the US, Scenario introduce a lightweight standalone CD-ROM reader

December
- In the US, PIMA announce that the projected consumer launch of CD-I has slipped to the first quarter of 1991

1989

March
- Intel release the DVI-compatible Pro750 Application Development Platform (ADP), and ship over 100 systems by the end of the year
- Intel and IBM propose to develop new boards, software and integrated circuits for DVI products as part of an agreement to develop Micro Channel Architecture (MCA) boards for IBM PS/2 computers

April
- Microware Systems, National Computer Systems, NV Philips and Sun Microsystems form a limited partnership, OptImage Interactive Services Company, to develop software tools for CD-I developers

May
- Philips present a videotape of full-motion, full-screen video on CD-I at the fifth annual meeting of the PIMA Producers Group in Washington DC
- Matsushita (whose brand names include Panasonic and Technics) and Sony join Philips to make and promote CD-I products, and work together to enhance the format's technical capabilities

June
- PIMA announce that they have reached some 200 agreements with developers to produce CD-I titles, and that 30 projects are in full production with 30 more in preliminary design stages

September
- Century Research Centre (CRC) of Tokyo join Philips as the sole distributor of CD-I authoring systems and tools in Asia (including Japan), providing marketing, sales, installation, after-sales service, maintenance and customer training
- Intel Japan KK establish a Market Development Office and open the Tokyo Media Labs to promote and develop the use of DVI technology in Japan

October
- The first demonstration of full-motion, full-screen video from a CD-I disc, at a meeting of CD-I licensees in Tokyo
- Philips and Renault announce the joint development of four CD-I discs for the EDIRIS service training programmes for distribution to Renault service stations worldwide
- Intel announce their real-time video (RTV) Version 1.5, which can compress 30 frames of video per second on a PC, with DVI technology
- Olivetti join Intel to provide DVI-compatible products for the European computer market

November
- Motorola join Philips International to develop Very Large Scale Integrated (VLSI) circuits for CD-I, which will include a chip to provide full-motion, full-screen video
- In the US, CD-I is the Grand Winner in the Video Category of *Popular Science* magazine's top 100 new ideas, 'The Best of What's New'
- In the US, Intel demonstrate a DVI technology on an IBM Token Ring Network, and CEIT Systems launch their DVI authoring package, 'Authology: Multimedia'

1990

February
- Philips announce release of the low-cost CD-I Starter System, and three new authoring systems: the 700 SN Emulation and Disc Building Platform, 800 MC Development Platform (for the Apple Macintosh) and 950 Publishing System
- Philips abandon the terms 'CD-V' and 'CD-Video' in favour of 'LaserDisc'
- In Washington DC, Philips Interactive Media and Capitol Video Communications form Capitol Disc Interactive to develop CD-I software for professional and consumer markets
- IBM release the M/Motion Video Adapter A card and associated software for the IMB PS/2 with Micro Channel Architecture
- Intel introduce the ActionMedia 750 series of DVI products developed with IBM
- In the US, Sony announce the formation of the Sony Multimedia Project division to support CD-ROM XA developers, introduce a new low-cost CD-ROM XA interface card (CDB XT), and unveil the prototype of a new mastering system for CD-ROM and CD-ROM XA

March
- In Belgium, NV Telecity announce the development of educational programmes, primarily on CD-I, with the Netherlands Broadcast Company
- In Mexico, Philips Mexicana and Capitol Disc Interactive announce that the Amparo Foundation of Mexico will use CD-I in their new museum in Puebla
- In the US, Bermac complete the first professional application of CD-ROM XA, in a training package for TetraPak which also uses videodisc in a Sony VIEW delivery system

April
- In the US, Capitol Disc Interactive produce the first commercial application of CD-I for the opening session of the American Defense Communications Association's Fourth Annual Forecast to Industry in Washington DC, on 17 April
- C-Cube systems announce the CL-550 single-chip image compression processor, which implement the proposed JPEG standard with a compression ratio of 20:1 without visible loss of quality
- In the US, Panasonic introduce the first commercially-available (analogue) optical videodisc recorder, the LQ-4000

June
- Philips IMS release the CDiNavigator authoring package
- In the UK, the First Multimedia Conference on Interactive CD in sponsored by Matsushita, Philips, PolyGram and Sony
- Philips International BV and Bertelsmann AG announce that they will work together to publish CD-I titles for the consumer markets
- Philips IMS and Rizzoli Corriere della Sera (RCS) announce that they will work together to develop and distribute CD-I titles for Italian and international consumer, educational and professional markets
- In the US, IBM announce the formation of a new Multimedia and Education Division
- In the US, Commodore announce CDTV at the Summer Consumer Electronics Show, for delivery in September 1990 at $895
- In the US, Pioneer release the first LaserDisc/CD combi-player to retail for under $500, the CLD-980
- Radius launch Radius TV, which incorporates television, video and audio input into a Macintosh II environment
- In the US, Warner New Media demonstrate the prototype of an optical disc player (codenamed 'Magilla') which combines features of interactive LaserDisc and CD formats in a consumer product
- In the US, Image Entertainment release the first 3D videodisc, *The Mask* (based on the first 3D videotape of the same name)
- New York University offers a two-year master's degree in Interactive Telecommunications, from the Tisch School of the Arts

July
- The European Laserdisc Association holds its first meeting, in Amsterdam
- In Japan, Sony release the Data Discman
- In the US, the Rock Ridge Group begin meeting to discuss extensions to the ISO 9660 standard for CD-ROM

August
- In the US, Philips Interactive Media Systems announce the launch of the Headstart CD-I authoring station, Balboa Runtime Environment, and the release of the *Green Book* to all CD-I developers, licensed or not
- In the US, RCA launch their own branded LaserDisc players
- In the US, Empruve demonstrate their electronic book with separate screens for text and video, Cornucopia

September
- In Australia, Philips and Keyway Computers announce plans jointly to develop the Antipodean CD-I market

- Kodak announce Photo CD, for release in 1992
- In the US, Sony launch the first industrial-quality omni-disc player, the MDP-1000, which can handle 30cm/12 inch and 20cm/8 inch LaserDiscs and 12cm/4.75 inch CD-DA audio discs
- Nintendo begin to roll-out the world's largest interactive point-of-sale network, with 1600 units in the US, and 700 in France, by Christmas 1990
- In the US, the World of Coca Cola exhibition in Atlanta, Georgia, includes the country's first permanent HDTV cinema, using Sony equipment
- In the US, the Interactive Video Industry Association (IVIA) changes its name to the Interactive Media Association (IMA) while, in the UK, the erstwhile British Interactive Video Association (BIVA), later the British Interactive Media Association (BIMA), settles on the British Interactive Multimedia Association (BIMA)

October
- Philips unveil the CDI 601 and CDI 602 'one-box' CD-I players for professional markets
- Sony demonstrate the prototype of a portable CD-I player with 10cm/4 inch colour screen and three-button control interface, and a compact disc mastering system which supports CD-ROM, CD-ROM XA and CD-I
- Commodore defer the release of CDTV to January 1991, and Philips say that CD-I will be in circulation by September 1991

November
- Philips NV announce the dissolution of Philips Du Pont Optical (PDO), Europe's largest manufacturer of CD-DA and LaserDiscs, with their purchase of Du Pont's 50 per cent share in PDO
- Philips and Maxwell Communications announce the formation of Maxwell Multi Media, to publish language teaching and other CD-I software
- VideoLogic demonstrate video compression/decompression boards for the PC and Mac, based on C-Cube's chipset and algorithms
- Microsoft release preliminary specifications for the extension of Windows into PC-based multimedia environments
- In the US, Pioneer Artists announce that the concert video of Madonna's *Blonde Ambition* will be released exclusively on videodisc, with the videotape release to follow in December 1991

December • The Japanese CD-I Consortium is formed, with backing from Philips, Sony and Matsushita

1991

January
- JVC announce their JVC Extended video compression algorithm
- Fujitsu announce plans for a set of five chips for image compression and processing in multimedia computers
- Philips demonstrate a Digital Compact Cassette (DCC), for release in 1992, which will play both analogue and digital audio tape cassettes
- Kenwood USA demonstrate the prototype of a recordable (write-once) consumer CD system
- In the US, Sky Pix announce a satellite broadcast system for pay-per-view services which uses image compression and videodisc technology

February
- In Japan, Aiwa release the Still Video DAT Storage System, which records digital audio and high-definition still frames on digital audio tape
- In Europe, the OSMOSE-I project of the European Commission's ESPRIT programme undertakes to develop a high-level Applications Programming Interface (API) an authoring platform for multimedia CD projects
- In the US, Helgerson Associates propose the CD-RDx (*sic*) specification for data storage and retrieval from CD-ROM in DOS, UNIX, Macintosh, Windows and other environments
- In the US, the Blockbuster video rental chain opens a videodisc preview theatre in Hollywood

March
- Philips adopt the MPEG standard for moving video in CD-I, but plan to release the first players, in the US in autumn 1991, without full-motion, full-screen video, to be 'retro-fitted' when standard MPEG chips become available
- Philips and Sony agree CD-ROM XA standards, as an extension to the *Yellow Book*
- C-Cube Systems demonstrate a single-chip decoder which can compress video in real time, the CL-550
- Iterated Systems demonstrate image compression/decompression hardware and software based on fractal geometry
- Microsoft announce the Multimedia PC (MPC) base case specification and Multimedia Extensions to Windows

- Hitachi demonstrate the prototype of a portable CD-ROM XA player
- IBM establish their own network of Multimedia Learning Systems for dealer training

April
- Commodore launch CDTV, without full-motion, full-screen video, but demonstrate CDXL on the full screen at 10-15 fps
- PIMA form three production units to make CD-I titles for the consumer market – PIMA Thousand Oaks (for games and other titles), the Art Space Group (specializing in the fine arts) and a music unit; a fourth, InfoAction, is later formed to develop adult reference and do-it-yourself titles
- The Rock Ridge Group submit two preliminary specifications to the US National Institute of Standards and Technology (NSIT), proposing extensions to the ISO 9660 standard for CD-ROM
- Digital Equipment Corporation (DEC) announce multimedia extensions to their workstations, and Microvitec form a multimedia division
- Panasonic announce a rewritable magneto-optical videodisc recorder (incompatible with any other videodisc format), for release in October 1991

May
- The European CD-I Consortium is formed, with plans for an inaugural meeting by September 1991
- Philips Consumer Electronics announce the establishment of a new consumer publishing company, Philips Interactive Media Europe (with subsidiaries in Benelux, France, Germany, Italy, Spain and the UK) under the umbrella of a new holding company, Philips Electronic Media
- Philips consolidate all development of CD-I authoring tools into OptImage Interactive Services Company, a limited partnership between Philips, Sun, Microware and National Computer Services
- Sony announce a recordable optical-magnetic 'mini-CD' with 6cm/2.5 inch discs, for release by the end of 1992
- In the US, Blockbuster Video conclude (after a 12-month study) that videodisc software is not yet 'strong enough' to warrant widespread distribution; Image Entertainment sign a distribution deal with Ingram/ US Laser Video Distributors to establish an 'extremely large' distributor network; and Columbia House launch a mail-order LaserDisc Club

June
- Nintendo announce plans to develop CD-based games, in different formats, with both Philips and Sony

- Apple announce QuickTime extensions to Macintosh System 7.0, to incorporate multimedia into virtually any Mac-based application
- In the US, Pioneer launch a combi-player/jukebox which can hold five CDs and one LaserDisc simultaneously, and retrieve data from any one in turn
- In the US, the Software Publishers Association forms an MPC Marketing Council
- In the US, Grid Systems launch a laptop computer with built-in CD-ROM drive

July
- Apple and IBM sign a letter of intent, agreeing to work together on new open system software platforms and technologies, including platform-independent multimedia products
- Philips and Sony launch low-cost CD-ROM drives with bundled software at the consumer market

August
- In Japan, Pioneer Video Corporation press their 100 millionth LaserDisc
- Sony launch the first combi-player to incorporate a computer, barcode reader and digital audio, the MDP-1100, at $795
- Sega Enterprises demonstrate the first 'holographic' arcade game on videodisc, *Hologram Time Traveller*

September
- In the US, Frox apply the principle of graphical user interface to a high-level 'front end' which integrates all the hardware elements in a home entertainment system
- In the US, the Nebraska Videodisc Design/Production Group announce the end to their annual Symposium, begun in 1979
- In the US, Matrox propose multimedia upgrades for the US Army's 14 000 Electronic Information Delivery Systems (EIDS)
- In the US, Sony release a 36 inch television with 16:9 aspect ratio which can display high-definition images (but not receive HDTV broadcasts), for $17 000

October
- In the US, Philips launch CD-I at the Ed Sullivan Theater in New York on 16 October, at a list price of $1000 (and estimated street price of $800) for the CDI-910 consumer player
- Prototypes of handheld CD-I players include Sony's Discman-style CD-I Viewer (with 10cm/4 inch colour screen) and a player from Kyocera, designed to fit within one-quarter of a standard briefcase

- AIM become PIMA (Philips Interactive Media of America)
- IBM launch the Ultimedia range of multimedia hardware and software products for the PS/2
- The MPC Marketing Council launch the Multimedia PC platform (including over 60 software titles) in New York on October 8
- An international consortium of hardware and software interests announces the Frankfurt File Format (FFF) for publishing on writable CD, based on the *Orange Book* specifications for write-once media

November
- Pioneer demonstrate the prototype of a combi-player which handles CD audio, CD-I and LaserDiscs
- Sony launch the Data Discman electronic book in the US
- Philips invest some $66m in the international video rental chain, Blockbuster Entertainment

December
- In the US, Microware Systems Corporation (MSC) form MicroMall Inc. to develop, build and install interactive point-of-sale/information (POS/POI) units based on CD-I technology
- In the US, *RePlay* magazine ranks Sega's *Hologram Time Traveler* as the third most popular arcade game of 1991, based on earnings

1992

March
- At Microsoft's Seventh Conference and Exposition on CD-ROM and Multimedia, in San Francisco, Philips' Gaston Bastiaens demonstrates full-motion MPEG video on CD-I with a clip from a James Bond film
- At the same event, Commodore's Jim Dionne reveals that some 80 per cent of CDTV buyers already own a computer, so the product will be repositioned to fit more closely into the Amiga product range
- In Japan, JVC and Sega ship the Wondermega video game machine, a handheld unit which plays cartridges, CD audio and CD+G discs
- In the US, Commodore launch two bundles of CDTV software at half the consumer market price, for use in school libraries and classrooms
- C-Cube Microsystems launch the MPEG Video Lab, an evaluation system for developers who are working with MPEG digital video products

April
- Philips launch CD-I in the UK on 28 April, at a list price of £599 including £50 worth of discs of the customer's own choice; other international launches, including Japan and Mexico, follow soon after

Appendix 5

Further reading

Many of these books and directories, as well as market reports, videotapes and software, are available by mail order from:

Future Systems Inc.
PO Box 26, Falls Church VA 22040 USA
Tel. 1-800-323 DISC (toll free in the USA, excluding Virginia)
Tel. +1 (703) 241 1799 (within Virginia or outside the USA)
Fax. +1 (703) 532 0529

DIRECTORIES

The CD-ROM Directory 1991, TFPL Publishing 1991
The CD-ROM Market Place 1991, Meckler 1991
Interactive Healthcare CD-ROM Directory, Stewart Publishing 1991
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International Directory of Interactive Multimedia Producers, Multimedia Computing Corporation 1990/91
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The Videodisc Compendium, Emerging Technology Consultants 1991
Who's Who in Multimedia, Interactive Multimedia Association (USA) 1991

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GALE, John, *Multimedia Technologies*, Information Workstation Group 1991
INTECO, *Multimedia in Europe*, Inteco 1990
INTECO, *Multimedia Focus Groups*, Inteco 1991
SYSTEMS DYNAMICS, *Multimedia Research Programme*, 1991
WILSON, Roger, *The Market for Multimedia*, Dragonflair 1991

INTERACTIVE MULTIMEDIA

AMBRON, S. & HOOPER, K., *Interactive Multimedia*, Microsoft Press 1990
AYRE, Jim, *A Beginner's Guide to Multimedia*, NIVC/EMC 1990
BERRY, Dianne & HART, Anne (ed.), *Expert Systems: Human Issues,* Kogan Page 1989
BOVE, Tony and RHODES, Cheryl, *Macintosh Multimedia Handbook*, QUE Corp. 1990
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FELDMAN, Tony, *Multimedia in the 1990's,* The British National Bibliography Research Fund 1991
HOFFOS, SIGNE, *MULTIMEDIA AND THE INTERACTIVE DISPLAY IN MUSEUMS, EXHIBITIONS AND LIBRARIES* (LIR REPORT 87), THE BRITISH LIBRARY 1992
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McINTOSH, Stephen Ian, *The Multimedia Producer's Legal Survival Guide*, Multimedia Computing Corporation 1990
MEGARRY, Jacquetta, *Compact Discs and Computers: Converging Technologies*, Kogan Page 1989
MILLER, Rockley, and SAYERS, John, *Videodisc and Related Technologies: A Glossary of Terms,* Future Systems 1991

REBANE, George, *Financial Model for Interactive Systems: Focus on Electronic Retailing*, Monitor Information Services 1987

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CD-I

ISBOUTS, Drs. Jean-Pierre, *The Producer's Handbook of Multimedia Authoring for CD-I* , Philips Interactive Media Systems 1991

LAMBERT, S. & SALLIS, J. (ed.), *CD-I and Interactive Videodisc Technology*, Howard W Sams 1986

PRESTON, John, et al., *Compact Disc-Interactive: A Designer's Overview*, Kluwer 1987

CD-ROM

ARMSTRONG, C.J., and LARGE, J.A., *CD-ROM Information Products, Volume 1: An Evaluation Guide and Directory*, Gower 1990

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LAMBERT, S. & ROPIEQUET, S. (ed.), *CD-ROM: The New Papyrus*, Microsoft Press 1986

SHERMAN, Chris (ed.), *The CD-ROM Handbook*, Intertext and McGraw-Hill, 1988

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BINDER, Roberta, *Videodiscs in Museums*, Future Systems 1988

DAYNES, Rod, *The Videodisc Book: A Guide and Directory*, John Wiley & Sons 1984

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SAETTLER, P., *A History of Instructional Technology*, McGraw-Hill 1968

PERIODICALS

CBT Directions
Weingarten Publications
38 Chauncey Street
Boston MA 02111-2301, USA

CD-ROM International
Transtex International
11 Rue du Marché Saint-Honoré
75001 Paris, France

CD-ROM Librarian
CD-ROM Professional
Meckler Corporation
11 Ferry Lane West
Westport CT 06880

Cogito
Verlag Hoppenstedt & Co
Postfach 40 06, Haverlstraße 9
D-6100 Darmstadt 1, Germany

Electronic & Optical Publishing Review
Learned Information
Woodside, Hinksey Hill
Oxford OX1 5AU, UK

European Multimedia Bulletin
Suite 202 – The Foundry
156 Blackfriars Road
London SE1 8EN

HD World Review
Meckler Ltd
247-249 Vauxhall Bridge Road
London SW1V 1HQ, UK

Hypermedia
Taylor Graham Publishing
500 Chesham House
150 Regent Street
London W1R 5FA, UK

Information World Review
Learned Information Ltd.
Woodside
Hinksey Hill, Oxford OX1 5AU, UK

Information Media and Technology
Hatfield Polytechnic
P O Box 109
Hatfield AL10 9AB, UK

Inside IT
Tossa House
Main Road
Smalley, Derby DE7 6EF, UK

Interactive Learning International
John Wiley & Sons
Baffins Lane
Chichester PO19 1UD, UK

Interactive Multimedia
Sigma Press
1 South Oak Lane
Wilmslow, Cheshire SK9 6AR, UK

Interactive Update
Alexander & Associates
Suite 1109, 28 West 44th Street
New York NY 10036 USA

Interactive Media International
I M Publications
104 St. John Street
London EC1M 4EH, UK

Intermedia
International Institute of
Communications
Tavistock House South
Tavistock Square
London WC1H 9LF, UK

Journal of Educational MultiMedia and HyperMedia
PO Box 2966
Charlottesville VA 22902 USA

Laser Disc Review
Philip Parr
P O Box 526
London SW10 9AB, UK

Media Letter
Myriad Technologies Inc.
PO Box 142075
Coral Gables FL 33114 USA

Multi Media
High Text-Verlag
Gabelsbergerstraße 52
D-8000 München 2, Germany

Multi-Media Computing
Nanton Press
Postbus 93, 3720 AB Bilthoven
Soestdijkseweg 332N
3723 Bilthoven, Netherlands

MultiMedia
19 Scarbrook Road
Croydon, Surrey CR9 1QH, UK

Multimedia and Videodisc Monitor
Future Systems Inc.
P O Box 26
Falls Church VA 22046, USA

Multimedia Review
Meckler Ltd
247-249 Vauxhall Bridge Road
London SW1V 1HQ

New Media
Hypermedia Communications Inc.
901 Mariners Island Blvd., Suite 365
San Mateo CA 99404, USA

Optical Information Systems
Meckler
Grosvenor Gardens House
London SW1W 0BS, UK

Screendigest
37 Gower Street
London WC1E 6HH, UK

Appendix 6

Addresses

This appendix lists principal contacts in the CD-I market. Comprehensive lists of professional associations, programme-makers and production facilities, hardware and software suppliers, dealers and distributors are included in the directories cited in Appendix 5. The telephone numbers here include international codes: within any one country, it is usually necessary to substitute '0' for the two-digit country code.

PROFESSIONAL ASSOCIATIONS

British Interactive Multimedia Association (BIMA)
6 Washingley Road, Folksworth
Peterborough PE7 3SY, UK
Tel. +44 733 242370, Fax. +44 733 240020

European CD-I Consortium
Philips Interactive Media Europe
Mullard House
1-19 Torrington Place
London WC1E 7HD, UK
Tel. +44 71 331 1569, Fax +44 71 580 6757

European LaserDisc Association
Kastanjrlaan 7, Building SFHS
PO Box 80002
Eindhoven 5600 JB, Netherlands
Tel. +31 40 736094, Fax +31 40 733512

CD-ROM Standards and Practices Action Group (CD-ROM SPAG)
c/o Jordan & Sons
Jordan House, Brunswick Place
London N1 6EE, UK
Tel. +44 71 253 3030, Fax +44 71 251 0825

Interactive Multimedia Association (IMA)
Suite 440, Techworld Plaza
800 K Street NW
Washington DC 20001, USA
Tel. +1 202 408 1000, Fax. +1 202 408 0361

PRINCIPAL PHILIPS' OFFICES AND STUDIOS

Europe:

Philips IMS World Headquarters
Building SFH-6, PO Box 80002
NL-5600 JB Eindhoven, Netherlands
Tel. +31 40 735 629, Fax +31 40 735 919

Philips Interactive Media Europe
Mullard House
1-19 Torrington Place
London WC1E 7HD, UK
Tel. +44 71 331 1569, Fax +44 71 580 6757

Japan:

Japan Interactive Media Inc.
Hitokuchizaka Building
4-3-31 Kudan Kita
Chiyoda-Ku, Tokyo 102, Japan
Tel. +81 33 221 3088, Fax +81 33 221 3086

Philips K.K CD-I Project Promotion Office
Philips Building
13-37 Kohnan, 2-chome
Minato-ku, Tokyo 108, Japan
Tel. +81 33 740 5011, Fax +81 33 740 5196

USA:

Philips IMS Authoring Group
11040 Santa Monica Blvd.
Los Angeles CA 90025, USA
Tel. +1 213 445 5704, Fax +1 213 479 7135

Philips Interactive Media Corporation
One Philips Drive
Knoxville TN 37914, USA
Tel. +1 615 521 4487

Philips Interactive Media of America (PIMA)
Suite 700
11111 Santa Monica Blvd.
Los Angeles CA 90025, USA
Tel. +1 213 473 4136, Fax. +1 213 479 5937

Philips Interactive Media of America (PIMA) Studios
11050 Santa Monica Blvd.
Los Angeles CA 90025, USA
Tel. +1 213 444 6504, Fax +1 213 477 4953

CD-I DEVELOPERS AND SUPPLIERS

New Media Productions
12 Oval Road
London NW1 7DH, UK
Tel. +44 71 482 5258, Fax +44 71 482 5258

The European Multimedia Yearbook 1992 lists over 150 suppliers of CD-I hardware, software, production services and consultancy in the European market alone (for more information, contact Multimedia Ventures, 22 Cornwall Road, London N4 4PH, UK, Tel. +44 71 272 2137, Fax. +44 71 281 4550). As well as principal manufacturers such as Philips and Sony, they include:

3T Productions, Ashton-under-Lyne, UK
Airtech SAV Ltd, Milton Keynes, UK
Amplifor GmbH, München, Germany

Anatome/Anacor, Montreuil, France
Animated Pixels (Publishing) Ltd, Southsea, UK
ANV Productions, London, UK
Art of Memory Ltd, Chipping Campden, UK
Beckett Fiennes Enterprises Ltd, London, UK
Bra Böcker AB, Hoganas, Sweden
Cambridge Training & Development, Cambridge, UK
CAT Benelux BV, Schellinkhout (NH), Netherlands
CAV, Amsterdam, Netherlands
CBI Context AB, Bromma, Sweden
CD Ideas, Kimpton, UK
CEMEI, L'Aquila, Italy
Chrysalis Interactive Services, London, UK
Clarinet Systems Ltd, Camberley, UK
CODIM Interactive Media CV, Eindhoven, Netherlands
Coktel Vision, Meudon la Foret, France
Convergent Communciations, London, UK
Creatividad Y Tecnologia S.A., Madrid, Spain
Decode Multimedia, London, UK
Design Information Research Team (DIRT), Uxbridge, UK
Educa Video Multimedia Design, Utrecht, Netherlands
EDUVISION, Maisons-Alfort, France
Epic Interactive Media Company Ltd, Brighton, UK
Europress Software, Macclesfield, UK
Freehand Ltd, Cranleigh, UK
Futuremedia Ltd (Group), Arundel, UK
Genova Ricerche Consortium, Genova, Italy
Hay Space Consulting Technologies, Milano, Italy
I Contact, Colchester, UK
ICL Interactive Learning Systems, Windsor, UK
ICONOMICS Laserdisc Bild und Träger GmbH, Wien, Austria
IMEDIAT, London, UK
IMF (Industrial Management Force) BV, Alphen aan den Rijn, Netherlands
Immedia Ltd, London, UK
INT'L CD-I, Charleroi, Belgium
INTER/AKTION, München, Germany
INTERACTIF-Delta, Marne la Vallée, France

Interactive Design AB, Göteborg, Sweden
Interactive Language Teaching Ltd (ILT), Slough, UK
Intersearch Systems, Stowmarket, UK
ISKRA Project SRL, Milano, Italy
Jeanne Verdoux, Paris, France
KimTec UK, Wimborne, UK
Klöckner Audio Vision, Duisberg, Germany
Koch Digitaldisc GmbH & Co. KG, Innsbruck, Austria
Level Plus GmbH, Düsseldorf, Germany
Limburgs Universitair Centrum, Diepenbeek, Belgium
Line TV, London, UK
Little Big One NV/SA, Brussels, Belgium
MABB Sistemas Interactivos SA, Barcelona, Spain
Main Image Ltd, London, UK
Martin Wright Associates, Tyneside, UK
Matthewson Associates, Tonbridge, UK
Maxwell Multi Media, London, UK
McMillan UK Ltd, Arbroath, UK
Media Design Interactive Ltd, Aldershot, UK
Media Projects International Ltd, London, UK
Mégaoctet, Paris, France
Meridian Data Europe BV, Geldrop, Netherlands
MikroGraf A/S, Aabyhoej, Denmark
MLS, London, UK
Moonlight Publishing Ltd, London, UK
More Spirit Ltd, London, UK
Morrison Company, London, UK
Moving Picture Company, London, UK
Multicom Info Systems, Darmstadt, Germany
MultiMedia Corporation, London, UK
Music Sales Ltd, London, UK
NAK Multimedia Productions, Montigny le Bretonneux, France
Next Technology, Cambridge, UK
NIAM Interactive Multimedia, Den Haag, Netherlands
Nielsen & Nielsen Film ApS, Copenhagen, Denmark
Nimbus Information Systems, Monmouth, UK
Noumena SRL, Napoli, Italy

Opus Species, Paris, France
Paralax Software Publishers, Maarsesen, Netherlands
Parsifal, Genoa, Italy
PLAN 1 OY, Tampere, Finland
Pro Lernen Beratungsgesellschaft, Wiesbaden, Germany
Psygnosis, Liverpool, UK
Recent Productions Ltd, London, UK
Reed Opti-Ware, Dunstable, UK
S.S.V.C., Gerrards Cross, UK
Seventh Storey Ltd, London, UK
SIDAC, Roma, Italy
Simulmondo SRL, Bologna, Italy
Skillchange Systems Ltd, Stevenage, UK
Softwareland AG, Zürich, Switzerland
SPIN UK Ltd, Croydon, UK
Stewart Atkins Multimedia Consultancy, London, UK
Techability, London, UK
Tecniware SRL/RCS Professoni, Milano, Italy
Telecity CD-I NV, Hasselt, Belgium
Telemedia GmbH, Gütersloh, Germany
Titus, Gagny, France
TOP MultiMedia BV, Hilversum, Netherlands
Ubisoft, Montreuil Sous Bois, France
UNI-C, Aarhus N, Denmark
Valkieser Multi Media, Hilversum, Netherlands
Vektor Ltd, Salford, UK
Victory Interactive Media S.A., Lugano, Switzerland
VideoLaser, Milano, Italy
Virgin Multimedia, London, UK
Wigant Interactive Media, Willemstad, Netherlands
Xebec Multi-Media Solutions, Nailsworth, UK
Xis - New Media Systems, Montpellier, France
ZAPfactor Ltd, London, UK

Indexes

GENERAL INDEX

COMPANIES AND INSTITUTIONS

PRODUCTS – COMPUTERS AND DEVELOPMENT TOOLS

QUOTES

SOFTWARE TITLES AD PROJECTS

CD-I Designers GUIDE

Signe Hoffos with Dr. Graham Sharpless, Phillip Smith and Nicholas Lewis from New Media

CD-I, digital video, interactive multimedia... *The CD-I Designer's Guide* provides a comprehensive introduction to this new world of communications for everyone interested in electronic publishing, entertainment, training, education and information services.

Compact Disc-Interactive (CD-I) combines the high-quality sound and pictures of a consumer entertainment product with the high-volume storage and processing capacity of professional computing. The result is a product as small and robust as any CD, with a compact player which connects directly to an ordinary television – a low-cost, versatile platform for entertainment, information, education and training in homes, schools, offices, factories and museums.

The CD-I Designer's Guide is essential reading for anyone interested in commissioning, designing, publishing or investing in multimedia. It includes:

- A comprehensive introduction to the concepts behind interactivity and multimedia.
- A detailed overview of all the new multimedia platforms, including CD-DA, CD+G, CD-ROM/XA, LasterDisc, IV, PHOTO CD, DVI, desktop video, CDTV and CD-I.
- Extensive examples of titles already developed, for consumer and professional markets, on all these platforms.
- Practical advice for designers and publishers on all interactive multimedia, with experience and examples from New Media and many other developers in Europe and the US.
- Detailed descriptions of CD-I discs and drives, audio and video processing facilities, programming and stages in production.
- A case history describing the production of *Japanese for Business Travellers,* one of the first CD-I titles for professional markets.

The CD-I Designer's Guide includes a large glossary of multimedia and CD-I terms, a timeline of multimedia development on all platforms, reading lists and contact information for companies and professional groups, and an introduction to the principles of audio-visual data storage for absolute beginners.

The CD-I Designer's Guide was prepared by Signe Hoffos, who has been writing about interactive multimedia for over ten years, and New Media, Europe's foremost multimedia developer, with a dozen CD-I titles and work in every platform from IV to DVI.

ISBN 0-07-707580-3

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McGRAW-HILL BOOK COMPANY

CD-I *Designers* GUIDE

Hoffos, Sharpless, Smith, Lewis